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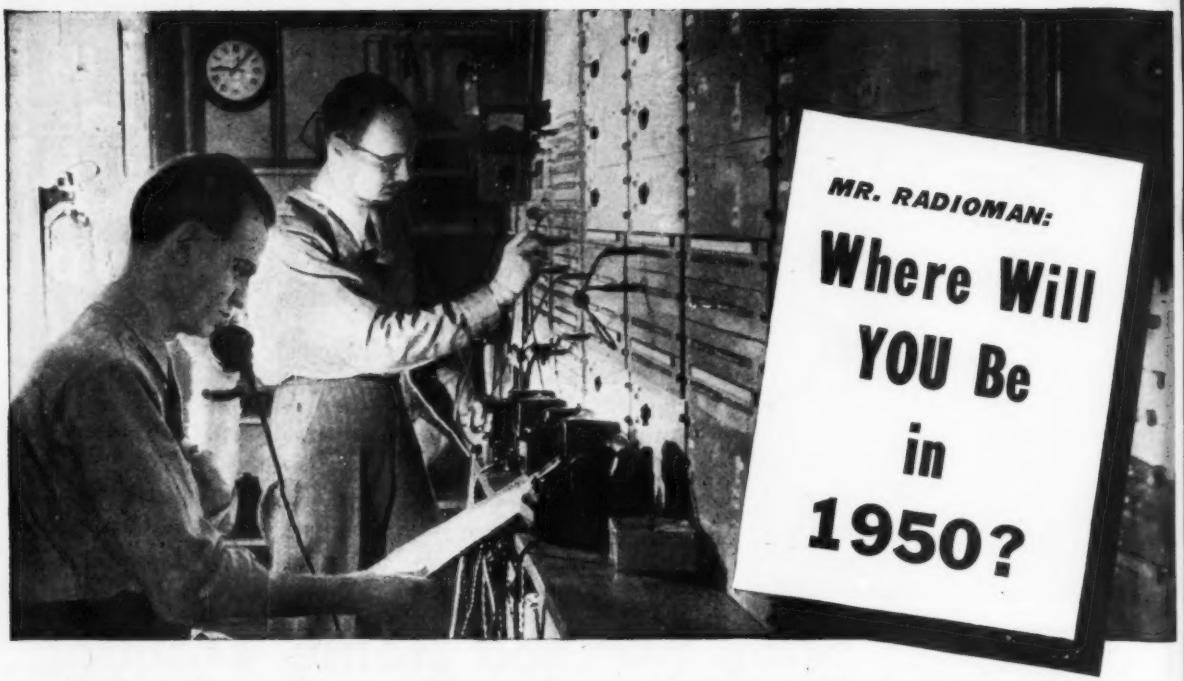


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By HUGO GERNSBACK

# WHY THE TUBE SHORTAGE?

## *The present tube situation is one of great complexity*

DURING the past few months we have received a number of communications from radio dealers and service people. The following is a good example:

*Editor,* RADIO-CRAFT:

"If I were running a radio magazine serving the Serviceman, I would try to find out WHY the tube situation today is worse than it was during the war and inform the serviceman and the public just what IS the truth.

"It would seem to me the customer, who supports the radio industry, should have first call on tubes, not the factory, who would only sell them more radios when they have enough and all they need is tubes to make them work.

"When so-called radio tube companies advertise batteries, pilot lamps, etc., and avoid mentioning RADIO TUBES which is their main article, I KNOW something is rotten. We don't WANT pilot lamps, batteries, what we NEED IS TUBES! TUBES!! TUBES!!!

"They were d—n glad to sell us tubes in prewar years when the factories gave them next to nothing for them, but now, there must be a black market, with greasing, etc., to get the tubes that the public needs.

"They promised great things when the war was over, or is it?? Is the army still taking most of the tubes? Is that what they feed the men? Every ad you see has something else, but no TUBES."

CHAMBERS & SON,
RADIO REPAIRS,
*Upper Darby, Pa.*

RADIO-CRAFT contacted a number of radio tube manufacturers, among them the largest in this country, and has gathered some information on the subject. This may serve to explain the present acute shortage and give an indication when it may be relieved.

To begin with, *officially* the war is by no means over. Very large numbers of troops are still gathered in many former war theatres from Europe to the Pacific. The Army, Navy, and auxiliary forces still maintain in use for communication purposes a great deal of radio equipment. They still consume large quantities of radio tubes, be it for new and more modern equipment or for replacement purposes.

Then, too, new trainees are still being inducted into the various services. Routinely they require large amounts of radio equipment. The Navy also still has a sizable portion of equipment afloat making it necessary to use practically all its shore radio installations. Naturally the military not only uses up millions of radio tubes, but also has priority on such matériel.

Strikes in many industries have slowed up many manufacturers — among them radio tube manufacturers. They have not as yet recovered from this slow-up, though the condition is being relieved slowly as this is written.

The complexities of modern radio tube manufacture is another reason given for the slow-down in tube production. Manufacturers have many divisions, or "units," which process different stages of production. Thus we have glass-blowing units, exhaust units, assembly units, etc. According to tube manufacturers contacted, present-day inefficiencies or shortage of certain supplies may cut output of a single unit as much as 20 percent, thus creating a bottleneck which may hold up other units which are not in themselves suffering from inefficiencies or scarcity of materials.

A rather large percentage of all labor employed in the production of radio tubes goes into the "mount." This term describes the already assembled part of the tube, comprising cathode, plate grid, etc., which is put together before the envelope is put on and the tube is ready for exhausting and sealing.

To obtain sufficient labor, during the war, it was necessary for tube manufacturers to establish so-called "feeder plants" in localities where quantities of skilled labor was available. These plants in many cases were relatively distant from the main factories, and their establishment and operation increased costs to a point that — now the war is at least unofficially over and the manufacturer has to face O.P.A. price regulations and a competitive market — consideration had to be given to closing them.

Let us now turn to the present receiving tube market, as compared to the prewar market. Prior to the shut-down of radio receiver production in 1941, the radio industry used approximately 100 million tubes for equipping their new radio receivers.

At that time the average requirement per set was 5½ tubes. The replacement market in prewar years averaged one out *(Continued on page 652)*

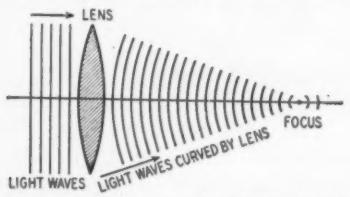
# RADIO-ELECTRONICS

## Items Interesting

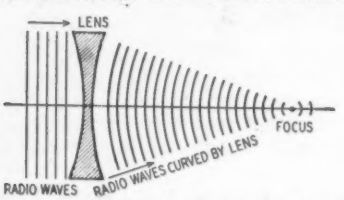
**A METAL LENS** which focusses radio waves as a glass lens focusses light is expected to fill an important role in microwave relay systems. Similar units, developed secretly for military use, distinguished themselves in comparison with older types of radio wave directors.

The new lens was designed and developed by Dr. Winston E. Kock and his associates of Bell Telephone Laboratories' technical staff.

It operates on a principle roughly akin to that of a simple convex magnifying glass. The action of the glass is to delay the advancing wavefront by an




Light waves slowed down by the convex glass lens and radio waves speeded up in the concave metal lens are bent in the same manner.




amount that is greatest at the center of the lens, where the glass is thickest, and least at the tapered periphery. As a result, the wavefront is reformed and headed so as to converge toward a point. This change in the velocity of a wavefront is a fundamental principle of all lenses.

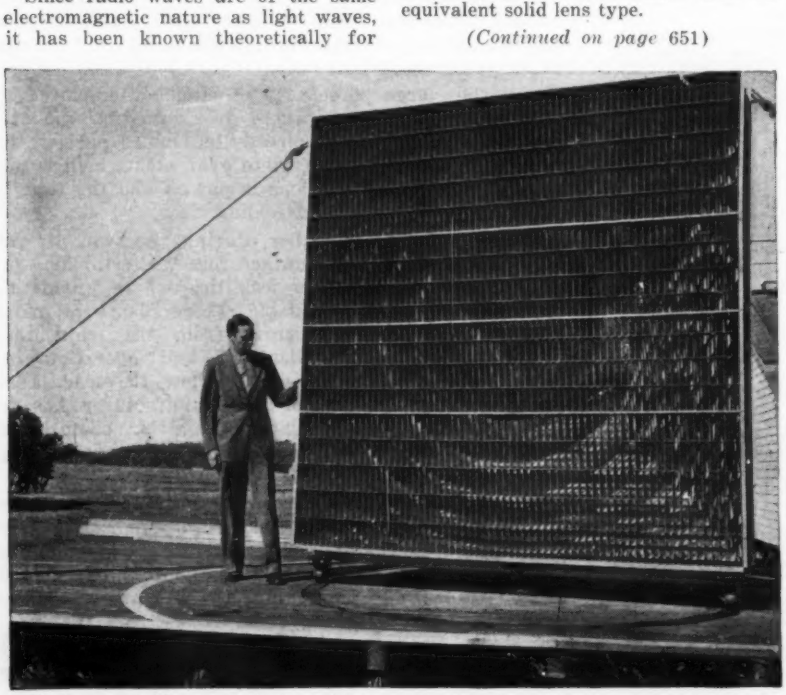
Since radio waves are of the same electromagnetic nature as light waves, it has been known theoretically for some time that radio lenses on this principle might be built. Previous to the advent of microwaves, there was an insuperable obstacle in the very much greater length of radio waves, which in the commercial broadcasting band range from an eighth to a third of a mile. For a lens to be effective, it should have a diameter of at least several times the wavelength. This would have meant a lens almost a mile wide.

It was in pondering this problem that Dr. Kock thought back to waveguides, those hollow tubes which one of his colleagues had devised some years earlier to conduct microwaves and which, in war, were to play so vital a role in supplying a physical channel for radar signals.

It was known that radio waves undergo a speeding up, or increase in wavefront velocity, when they pass along such a tube or between metal plates and that the total advance of the wavefront could be fixed by controlling the length and contour of the plates and the distance between them.

It occurred to Dr. Kock that an array of metal plates could be designed to focus radio waves just as effectively as a solid lens might focus them if due regard were given to the fact that the edges of the wavefront would be advanced rather than retarded in transit. Such a structure would also be easier to build, move and maintain than an equivalent solid lens type.

*(Continued on page 651)*



This large metal lens concentrates radio waves more sharply than can any other director.

**CAPACITOR** manufacturing methods may be revolutionized by a machine discovered in Germany and now brought to the United States for study, it was announced by the Department of Commerce last month.

This new machine, a development of the Robert Bosch concern, of Stuttgart, Germany, produces paper condensers without the conventional metal foil. The plates of the condenser are formed by coating the sides of the paper with a very thin layer of vaporized zinc. This machine may be expected to reduce the production costs of paper condensers by twenty percent.

**V-2 ROCKETS,** equipped with radio apparatus, will give scientists new information on our atmosphere up to a height of 100 miles, according to information released last month by the Army Ordnance Department. The rockets, taken from a captured German factory, will be equipped with apparatus to register and transmit information concerning temperature, pressure and other meteorological information, as well as reports (velocity, acceleration, altitude) on the progress of the rocket itself.

The V-2 is expected to reach a speed of 3500 miles per hour, and will land eighty-seven miles from the starting point. The flight will take seven minutes, and is expected to collect enough data in that time to keep a group of scientists busy for several weeks. The Army Ordnance Department expects to gain from it information on rocket flight which may be of great value in designing future aerial projectiles.

**RADIO-CONTROLLED** crewless airplanes will "watch" the atomic bomb tests over Bikini, the Navy Department stated last month. The planes, four in number, will fly at different levels into the turbulent air storms created by the blast.

They will carry devices to capture samples of the gases created by the blast and to record radio activity and other characteristics of the churning air mass.

Guide planes, bearing live crews, will fly 12 to 30 miles from the atom blast, thus being outside the danger area, the Navy Department reported.

**BRITISH TELEVISION** will resume war-caused interruption of almost seven years on the seventh of June at 3:00 pm, a British Broadcasting Co. notice announced last month.

Pre-war practices, including the 405-line standard will be used. Thus pre-war receivers can be put into action with no modification, the report stated.

# MONTHLY REVIEW

## *to the Technician*

**MORE FM** receivers were urged by the FCC, after a survey of manufacturers made last month. The eighty-four companies covered in the survey reported an expected output of 1,800,000 FM receivers for 1946. In addition, they expected to make converters and adapters numbering something less than 100,000, as well as 50,000 combination FM, television and broadcast sets.

Pointing out that applications were on hand for 834 FM stations, the FCC urged that manufacturers revise their production schedules to increase the number of FM sets.

**RADIO SET PRODUCTION** for 1946 will fall "far below" the FCC prediction of twenty million receivers, stated J. D. Secrest of the RMA publications bureau last month.

Calling the FCC report "a lot of wishful thinking," Secrest said the estimated volume for the first quarter of this year is only two and one-quarter million. While it is possible that production might hit two million sets a month by mid-summer, he added, the FCC figure definitely will not be reached, due largely to component shortages and an OPA bottleneck.

The Commission's estimate was nearly 50 percent higher than the peak pre-war year, 1941, when receiver output was 14 million.

**"SPY RADIOS"** picked up at various points in occupied Italy, were revealed last month to be ordinary radiosondes, released by American meteorological services and plainly marked as U. S. Government property.

A pint-size spy scare had been aroused before the true nature of the mysterious instruments was revealed, and at least two European powers were accused by opposing factions of undercover intervention in Italian politics.

The scare reached even to the United States, and reputable American papers pointed out solemnly that the transmitters were of the "tiny type suitable for agents inside enemy lines." The label "Notice to finder; this instrument belongs to the United States Government," according to the same source, "signified only that it is pretty certainly not Americans who are dropping the radios, as there could be no conceivable reason for the Americans or British to use that method to distribute any radio apparatus they wished to distribute in Italy."

From the description, the radios were very standard radiosonde apparatus, and apparently could not have been turned over to technical personnel for inspection, as the barometer and hygrometer, contained in each, as well as the highly special switching system, would have identified them immediately.

**COMMUNITY** radio broadcast towers may become the rule in the future, according to engineers of the Federal Telephone and Radio Corporation, who started construction of such a unit at Nutley, New Jersey, last month.

The Nutley tower will be experimental. It will house as many as twelve FM sending units on different channels, six color and four black-and-white television transmitters, six police radio networks serving as many different communities with signals, as well as experimental pulse - time - modulation transmitters for beamed-radio links to other cities miles away.

The tower will, its builders hope, become a center of experimental work on microwaves from which much of the services of tomorrow will spring. The waves from the 300-foot structure will run the gamut of the high frequencies from the "medium hundreds to the many thousands of megacycles."

Two strong arguments favor the community arrangement. Joint financing would make better facilities more feasible, and the tower could be put at the location giving the most effective coverage of the area served (ideal spots are not too plentiful in most communities).

**TELEVISION** links between Moscow and Leningrad and separate studios in the cities of Kiev and Sverdlovsk are planned for the near future, a report from Moscow announced last month. Soviet radio experts expect that by 1950 thousands of Russian sets will be receiving television in full natural colors.

Television broadcasts now are made twice a week to an area within thirty-five miles of Moscow. Daily broadcasts are expected to start this year. Clarity and reception have improved and by next year should equal the quality in the United States, the Television Center said. Only one-color broadcasts now are attempted, but equipment is being developed for colored showings.

**ELECTRONIC** night sight reduced the infiltration menace in the Pacific war theatre, it was revealed last month by R. H. Frye of the Electronic Laboratories, Indianapolis.

The device (known as a "snooperscope") looks like an ordinary short telescope such as may be seen in various sighting devices, with an additional disc-shaped object mounted just below it. The disc is in reality a very powerful infra-red lamp and lens, projecting a beam of invisible "black light."

The infra-red rays, reflected from objects in their path like ordinary light, operate the receiving end of the instrument. Though this looks like an ordinary telescope, it is more like a television

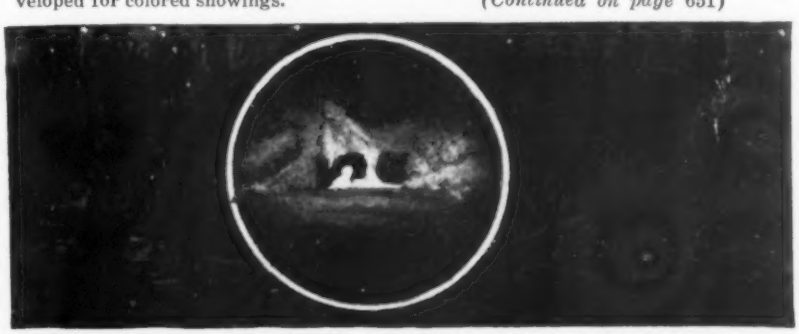
The portable Snooperscope and power supply. A modified form of the instrument, called a Sniperscope, attaches directly to a carbine.

tube. Only the lens at the front of the tube is a real optical device. The reflected infra-red rays are picked up by this objective lens and focussed on the image tube, causing a photo-sensitive screen to emit electrons in direct proportion to the intensity of the invisible rays.

These electrons proceed down the tube, accelerated by high-voltage electrodes, and strike an ordinary fluorescent screen at the other end, causing it to glow and thereby producing a visible image which reproduces faithfully the details of the original scene. Thus the rays pass through three stages—beams first of infra-red "light," then of electrons, and finally of visible light—before reaching the eye of the beholder.

All power for the apparatus is sup-

*(Continued on page 651)*



The figures coming out of the dugout are quite invisible to unaided night-adapted eyes.

By MILTON S. KIVER

# TELEVISION FOR TODAY

## *Part I—Some Fundamental Principles*

A KNOWLEDGE of fundamental radio principles is definitely essential to an understanding of television. The theory and operation of standard broadcast sound receivers is now well known. This does not imply that an automatic transition to modern television can be made, in spite of the number of similarities between the two systems. Many circuits are entirely new and different. It is the purpose of this series to help bridge the gap between the already well-known facts of radio as manifested in broadcast transmission and reception of today and the lesser-known features of tomorrow's television.

*Courtesy Belmont Radio Corporation*
**Postwar television receiver with 7-inch tube.**

Before we attempt any comparison of the two systems, let us determine briefly what components form a complete television system, from the transmitter at the broadcast station to the receiver in the home.

First, there is the scene to be televised. This scene must by some means be converted into an equivalent electrical pattern, thus rendering it suitable for transmission to our receiving antenna. In the sound transmitter, a microphone is the converter. In the television system we employ a *camera tube*. Within this tube the incident light rays from the scene are brought to focus upon a photosensitive plate. The resulting physical actions produce a charge distribution on the plate surface that is suitable for conversion into electrical currents, known as the *camera signals*.

Second, there is the problem of how these electrical currents are to be utilized. As every photographer knows, a negative is nothing more than a collection of tiny silver compounded grains which have been acted upon by light. In the television camera, much of the same situation exists. The focused light has produced a change in each of the photosensitive globules deposited on its plate. Now we must dissect the image in order to transmit it. We could, if we wished, connect a complete transmitting circuit to each element (globule) and send the entire picture at one time. This would prove far too difficult. Much simpler in practice is the method whereby an electron beam *scans* across the image in a series of 525 horizontal lines. These follow in a predesigned order and are reconstructed in identical manner at the receiver. Thus the image is broken down at the transmitter, sent in fragments and then reassembled at the receiver.

This method of transmission poses yet another problem, that of *synchronization*. As long as we are sending the image in a series of lines, some form of identification must be inserted, along with the signal, to indicate to the receiver just where one line ends and the next begins. Failure to keep both the transmitter and the receiver in step would render it impossible to reproduce an identical image at the receiver. Synchronization is accomplished by inserting a series of pulses into the television signal at the end of each horizontal line. We have one set of pulses for the end of each horizontal line and another set of pulses, known as the vertical synchronization pulses, to bring the electron scanning beam back to the top of the image after the bottom line has been traced out.

During the short intervals of time that the synchronization pulses are notifying the receiver circuits to move the beam into position for the following information, a *blanking pulse* is also active. Its purpose is to prevent the electron beam from reaching the viewing screen. Without this precaution, we would actually see a trace as the beam moved from the right-hand part of the image to the left-hand side for the start of the next line. Since no signal is being

*(Continued on page 638)*

**Milton S. Kiver was born in New York on November 5, 1918, just a trifle too late to make the first World War. Became interested in radio as a hobby and as a result majored in Physics and Mathematics in college. After graduation and several years of odd jobs in radio, became associate instructor in radio engineering for the Army Air Forces. From here to Illinois Institute of Technology and thence to the Navy for 27 months in the radar program. At present on the engineering staff of American Television Laboratories of Chicago.**

**Mr. Kiver is author of numerous articles in technical publications and of two books, "UHF Radio Simplified" and "Television Simplified."**

**Fig. 1—The complete video signal for one line. The high points are synchronizing pulses. All values are reversed at the grid of the cathode-ray viewing tube.**

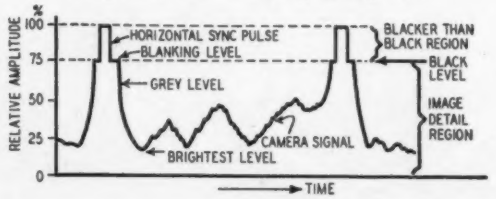
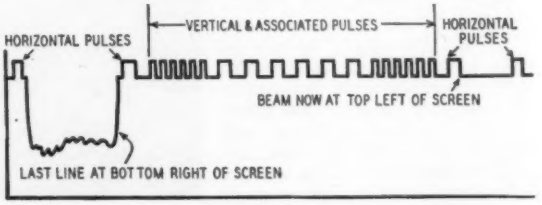



**Fig. 2—The vertical pulse contains horizontal pulse components, as shown. The whole pulse is in the blacker-than-black region, and makes no trace on the screen.**


HORIZONTAL PULSES
VERTICAL & ASSOCIATED PULSES
HORIZONTAL PULSES
BEAM NOW AT TOP LEFT OF SCREEN
LAST LINE AT BOTTOM RIGHT OF SCREEN

By I. QUEEN

# FM CARRIER STABILIZATION

## *Part II—Western Electric, Westinghouse, RCA Circuits*

THE previous article described the need for control of the center frequency of an FM transmitter and showed that direct crystal control is not possible. Several commercial contrcl systems were discussed. Others are described below.

A small but effective unit is responsible for carrier control in Western Electric FM transmitters. The heart of the system is a small induction motor which controls the tuning condenser in the plate circuit of the oscillator. The latter frequency is approximately 6 mc, which is multiplied by 16 (doubled four times) in succeeding stages to reach the new FM broadcast band of approximately 100 mc.

A portion of the 6 mc oscillator output is fed to frequency dividers which reduce the frequency by a factor of 1024 and therefore produce a frequency between 5377 and 6586 cycles, depending upon the assigned carrier. A crystal oscillator, operating on this same frequency, is also used.

These two frequencies are applied to the stator windings of an induction motor such that the beat frequency between them acts to turn the rotor. Thus, when the station is exactly on its correct frequency the motor is stationary, but if there is a drift in either direction, the rotor experiences a torque in the corresponding direction. The motor can take care of a change of about 50 cycles per second, equivalent to about 50 kc per second at the oscillator.

Because of its inertia, the rotor is not actuated by the relatively rapid modulation changes, but the more gradual oscillator drifts are promptly corrected.

### WESTINGHOUSE CIRCUIT

These circuits are based on methods of pulse generation and control which were developed during the war in connection with radar. As in other systems a crystal-controlled reference frequency is used as the standard with which the signal frequency is compared. The master oscillator frequency is 1/9 that of the assigned carrier. The reference crystal frequency, temperature controlled, is equal to one-half of the m.o. frequency and its second harmonic is therefore used for comparison.

The output of the reference frequency $F_R$ is divided into two parts. One is advanced in phase by 45° and the other retarded by the same angle. Each is mixed with FM oscillator output ($F_s$) in a separate 6SA7 tube. (Fig. 1). As a result, the beat frequency output of each mixer tube is displaced by 90° from the other. When the signal frequency ($F_s$) is the greater the output at B leads A by 90° and it lags by 90° when the crystal frequency is greater. When the two are equal there is no beat frequency. (See Fig. 2.)

The output of A actuates a direct-coupled multivibrator (Fig. 3), which amplifies and flattens the peaks of the sine waves. Because the tubes are greatly overloaded, the flat portion of the square waves is reached at about the time the sine wave passes through zero. The square waves are transmitted through an integrating R-C circuit which limits the horizontal or constant portions but passes the sharp changes in voltage. As a result, voltage pulses appear across each resistance with points D and E out of phase. The pulses are drawn for two conditions: $F_s > F_R$ and for $F_s < F_R$.

A 6H6 pulse detector (Fig. 4-a), now receives the pulses and also the sine wave output of mixer B. The tube is biased just beyond the peak value of the wave. As shown in Fig. 4-b, the pulses add or subtract from the sine waves, depending upon whether the FM oscillator frequency drifts higher or lower and upon which diode plate the measurement is made. Because of the bias voltage there will be either no output at all or merely the pulse output, depending upon whether they oppose or aid. Note that the output of B appears in the same phase at F and G.

The next stage consists of four charging rectifiers designed to charge

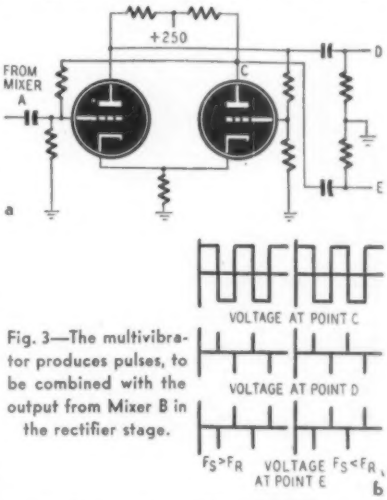



Fig. 3—The multivibrator produces pulses, to be combined with the output from Mixer B in the rectifier stage.

or discharge the condenser C according to polarity of the pulse input. These rectifiers are shown in Fig. 5-a and also at the lower right of Fig. 6, the complete schematic, including circuit parts as is shown in Figs. 1 to 5. Since current can pass through the input condensers

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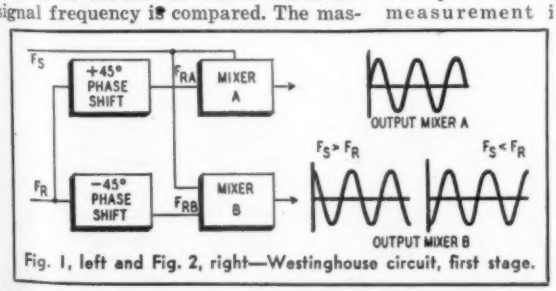
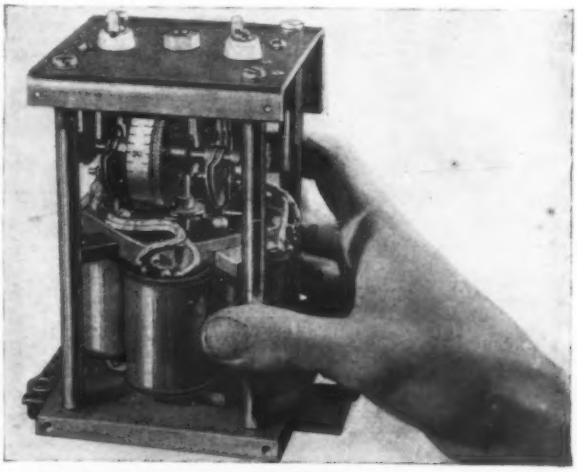



Fig. 1, left and Fig. 2, right—Westinghouse circuit, first stage.



This little motor is the heart of the Western Electric stabilizer.

in either direction because of the full-wave connection, the rise in the pulse will produce current in one direction, and the corresponding fall reverses the current. Results shown in Fig. 5-b are for a condition in which the FM oscillator is first lower than the crystal frequency and then drifts to a higher value.

Referring back to Fig. 4, it is seen that the voltage pulses at H are responsible for current at K, but that as the frequency drifts upwards this current disappears and instead current flows at L, due to voltage pulses at J (in Fig. 5).

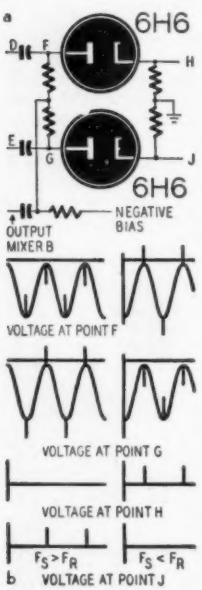



Fig. 4—The rectifier.

Current through M and N can only flow in one direction, evidently upward in each. Therefore current at M must raise the potential across C. Likewise current at N lowers the condenser voltage. These are shown in Fig. 5. Since there is no bleeder resistance across C (Fig. 6) its voltage is governed only by the frequency difference between the two oscillators.

The voltage across C changes the grid voltage of a 6SL7 cathode follower in such a way that the bias voltage for the modulator control tube is varied. Changing the grid voltage (of the 6SL7) thus changes the current through the control tube (Fig. 7), and this affects the equivalent resistance of the two 6H6 modulator tubes. Each diode shown is really two sections of one tube connected in parallel. The resistance variation changes the frequency of the oscillator tubes in a direction to correct for their drift.

This system eliminates all moving or critical parts. Except for the oscillator tank it does not contain any tuned circuits. Even tube aging does not affect the operation, since they are used merely as electronic switches and do not operate on the critical portion of their characteristics. Carrier deviation is held to a maximum of ±1000 cycles, far below that permitted.

## RCA "DIRECT" FM

Some of the principles previously described are used here, but under different conditions. For example, a two-phase motor controls the tuning and a reference crystal oscillator is also part of the circuit. A two-phase output is obtained from the latter by means of two balanced modulators.

The FM modulated oscillator tube is a 6V6 operating within the range 4.5-6.0 mc, which is divided by 240 in four stages. These stages use the so-called *lock-in* circuit developed by Beers, as shown in Fig. 8. A tuned circuit must be used but it results in a much better wave-form than that of a multivibrator and therefore does not require filtering. The lock-in range holds for frequencies within ±5 percent of the desired subharmonic. Tuning is accomplished by an iron slug within the coil.

The reference crystal oscillator operates within the convenient range 94-125 kc, and a divider (by 5) brings it down to the same frequency as obtained from the FM oscillator. The divided crystal frequency is now (Fig. 9), applied across two phasing circuits which causes the outputs to differ by 90°, and these together with the divided FM oscillator frequency are connected across two balanced modulators. As in the previously described system, the output will be two-phase current with a 90° difference. Whether one phase leads or lags the other is determined by whether the FM oscillator is less or greater than the correct frequency. Thus, the motor experiences a torque in the proper direction and its magnitude depends upon the correction to be made.

The induction motor can start with as high as 1000 cycles per second input. To eliminate friction and lost motion, the tuning condenser is mounted directly on the shaft. At no time is the rotor required to turn over more than ±45° to provide full frequency correction. The windings are of sufficiently high impedance to be operated directly in the plate circuits of the four 1614 type (equivalent to 6L6) motor (modulator) tubes. Therefore all frequencies down to d.c. may be transmitted.

Frequency modulation is accomplished by the *direct* system using a reactance

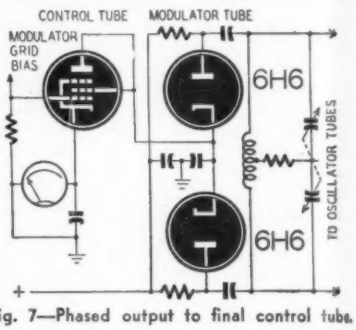



Fig. 7—Phased output to final control tube.

tube. This method is simple and is well known and used by amateur FM stations. Its principle is as follows. The reactance tube is connected in parallel with the oscillator tank, with a 90°

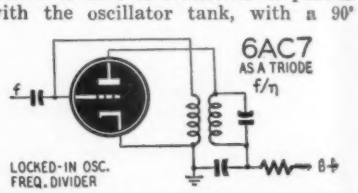
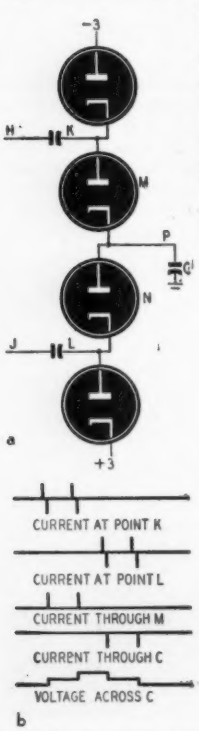



Fig. 8—Circuit of lock-in frequency divider.

phase shift applied between its plate and grid. (Fig. 10.) As an example, a condenser may be used between plate and grid and a resistance between grid and cathode. If the magnitude of the latter may be neglected in comparison with

*(Continued on page 637)*



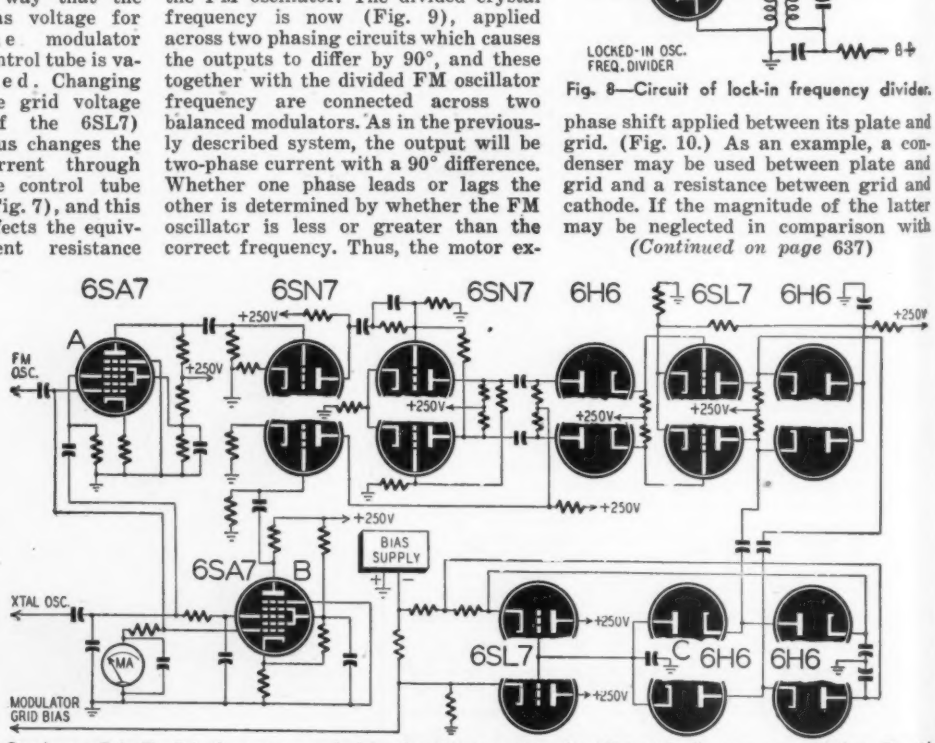




Fig. 5 (above) and Fig. 6—Condenser C in Fig 5 is the one so marked in the 6H6 output to the 6SL7 grids (bottom row of tubes, Fig. 6).

By M. CONTASSOT

# THREE-CHANNEL AMPLIFIER

## *A 15-Watt Unit with Individual Control of Each Channel*

WE must never lose sight of the fact, in considering the construction of any sound apparatus, such as an amplifier of frequencies in the musical range, that it is the ear which judges the excellence of the instrument—absolutely without appeal. It is therefore indispensable to examine the conditions under which that organ functions, to adapt our sound equipment to it in the best possible manner.

The sensitivity of the ear varies as a function both of the frequency and intensity of the sound. If we consider very weak intensities, the ear hears medium register sounds much better than basses or high-frequency notes. At medium intensities, all the frequencies are heard equally well, and for very loud sounds, the basses and highs are perceived with greatest intensity.

### THE CURVE OF AN AMPLIFIER

It appears from the considerations above, that the principle that leads to giving an amplifier a linear frequency curve is completely illogical. It is necessary to so design the equipment that the listener will hear the sounds reproduced under conditions which approach as close as possible those of listening directly to the sound source itself.

Let us take, for example, the case of a symphonic orchestra. If the listener is in his orchestra seat in the auditorium where the orchestra plays, he hears the music at such an intensity that his ear perceives it with the same relative sensitivity over the whole range of musical frequencies. But if he hears the same program over his radio or from records, through a loud speaker in his own living-room or bedroom, it is obvious that that intensity will not be as great—the size of a private room being considerably smaller than that of a concert hall. If he turns up the volume control to get the same sound level (which is possible) the neighbors with different musical tastes—or those who desire the sleep of the just—will not be slow in protesting energetically. He will therefore regulate the volume to a sound level rather on the weak side.

It is then that the ear registers its discontent with this "sound rationing" by refusing, as just pointed out, to hear the low and high notes with the same force as the frequencies in the middle of the audible spectrum. But, if our critical listener is clever and especially if he constructs his own amplifier, he will design it with such a response curve that it overamplifies the highs and the basses relative to the medium frequencies, *to exactly the same extent as the ear tends to weaken them.* He thus does his own ears a good turn, at the same time restoring the musical equilibrium.

### THE DESIRED AIM

To establish the response curve of which we have just spoken, it is necessary to know that of the ear. That curve has been traced by the physicians and physiologists, who have established it by the average of several thousands of individual cases.

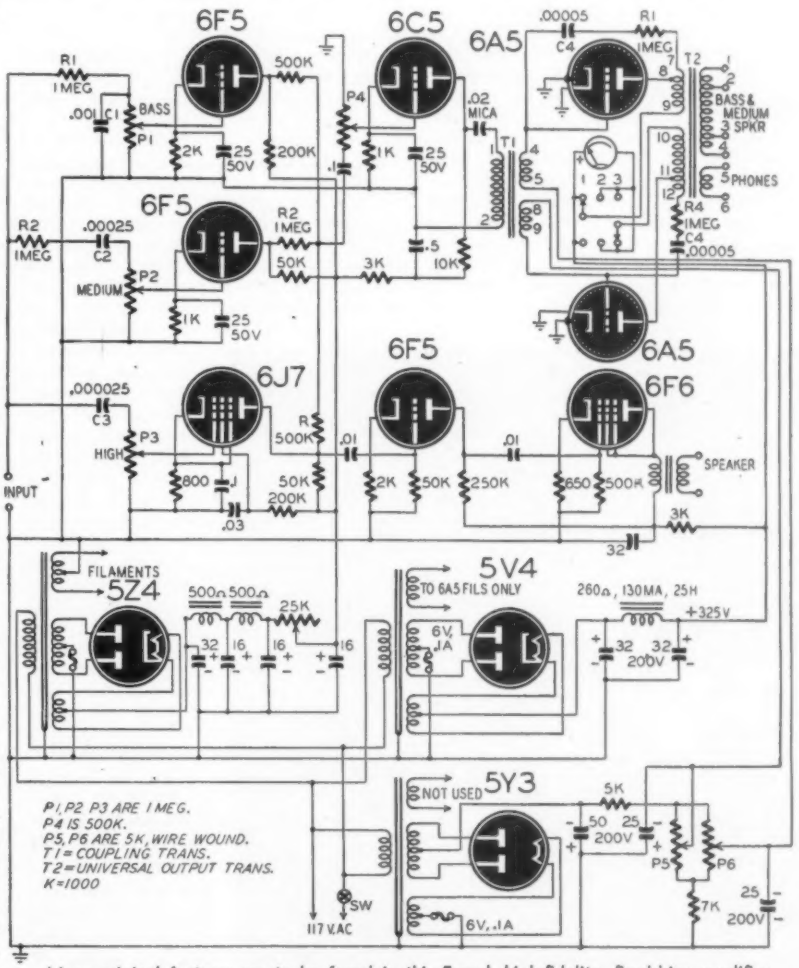
Since the amplifier is destined for the pleasure of one sole listener, it may well happen that the particular ear in question will be very different from the "average ear." Therefore it is infinitely preferable to permit the user to adapt the amplifier response to his own needs and tastes.

It is with this idea that the amplifier here described was conceived. It has three channels, one for each band of frequencies: bass, medium and high, the amplifier for each channel being controllable independently of the others.

### DESIGN AND CONSTRUCTION

We shall scrupulously avoid the hackneyed description of: "the tube A, plate of which is coupled to the grid of tube B through the blocking condenser C, etc.," refusing to consider the reader so benighted that it is necessary to point out that which he can see clearly in the accompanying schematic drawing.

*(Continued on page 642)*




Many original features are to be found in this French high-fidelity, fixed-bias amplifier.

COVER FEATURE

# HIGH-POWER U.H.F. TUBE

## *Triode Penetrates Far Into the High-Frequency Spectrum*

COLOR television owes much to wartime radar, for the high-frequency triodes represented by the 6C22 were developed originally as radar transmitter tubes. The 6C22 itself is a modification for continuous-wave operation of an older radar tube known as the L600E. This tube was capable of delivering pulses up to a peak power of 25 kw, but was not altogether suitable for non-pulsing applications. The 6C22 was then developed by engineers of the Federal Telecommunications Laboratories for continuous duty. Working as an r.f. amplifier, it is capable of power outputs of 600 watts at frequencies up to 600 mc.

The tube is of remarkably small size for its output, as will be seen from the cover picture and the illustration on this page. Such economy of dimension is necessary for operating at the high frequencies for which it is employed. Internal construction may be seen in Photo A. The squirrel-cage structure in the left-hand portion is the grid. It consists of thirty-two .008-inch diameter wires spot-welded to and supported by a low-inductance cone, which is attached to the grid ring, seen just above the tube base. The anode is made from a solid copper cylinder. In one end is a cavity into which the grid fits; the other or water-jacket end is slotted. Spacing between the grid and anode is very close—this being another feature necessitated by the high frequency at which the tube is to work.

The filament of a high-power, ultra-high-frequency tube presents special problems. Due to transit-time effects, not all the electrons emitted by the filament or cathode when the grid is positive reach the anode. Many return to the cathode space-charge region. This causes a decrease in anode current and power output. To increase the current, the cathode must emit a greater number of electrons to compensate for those which do not reach the anode. The required emission may be several times as great as in low-frequency applications where transit-time effects do not have to be considered.

| CHARACTERISTICS, 6C22 | | |
|---|---|---|
| Filament | | Thoriated Tungsten |
| Filament Volts | | 6.5 |
| Filament Amperes | | 18 |
| Amplification Factor | | 9 |
| Mutual Conductance (ma/volt) | | 13 |
| Maximum Anode Dissipation (Kilowatts) | | 2 |
| Maximum Anode Volts | | 3,000 |
| Maximum Grid Dissipation (Watts) | | 25 |
| Capacitances μμf. | Cgp | 6 |
| | Cgf | 7 |
| | Cpf | 0.4 |

The filament is therefore a thoriated tungsten wire of .025-inch diameter, coiled in a bifilar helix inside the grid assembly. It has an active emissive surface of three square centimeters. Spacing between grid and filament is held to a minimum.

Characteristics of the tube are shown in the table. Most of recent studies on it have been made at 600 mc. At this frequency, in a neutralized inverted amplifier circuit, with 1600 volts on the anode and a current of 0.65 ampere, the power output is in the order of 500 watts. A driving power of 190 watts is required.

Photo A—The portion at right is the anode end. The grid is visible in the other half. Operator is aligning the tube elements before the sealing off.

### THE COLOR TRANSMITTER

The high-definition color television transmitter built for the Columbia Broadcasting System by Federal Telephone and Radio Corp. operates on a frequency of 490 mc. It can be modulated uniformly with all frequencies from zero to ten megacycles, and is the most powerful transmitter of this frequency and modulation bandwidth yet installed.

Four 6C22 tubes are used in the radio-frequency section of the transmitter and three in the video-frequency modulator. The r.f. section starts with a 6V6-GT crystal-driven at 6.805 mc, and is followed by a number of conventional stages which multiply the frequency to 122.5 mc and amplify the power to 120 watts. This is followed by a 6C22 in a co-axial circuit operating as a frequency doubler, which delivers 250 watts at 245 mc. The co-axial amplifier is shown in Photo B. The anode circuit is a quarter-wave line shorted at the end farthest from the tube. Tuning is by a movable piston.

Another 6C22 doubles from 245 to the final frequency of 490 mc. The stage operates as a grounded-grid amplifier, and delivers 300 watts to a 6C22 neutralized amplifier, which also operates as a grounded-grid stage, and delivers approximately 700 watts at 490 mc. This is considerably more than is needed to drive the final to its full peak power of 1 kilowatt, but the excess power is dissipated in a damping resistor attached to the coupling line between the driver stage and the final modulated amplifier. This resistor acts to maintain constant output voltage from the driver stage in spite of the output stage's changing load as its bias is varied through the modulation cycle. This improves the linearity of the modulation characteristic and reduces somewhat the voltage required from the modulator stage.

The final, or modulated amplifier stage, also uses a 6C22 in a neutralized, grounded-grid circuit. With a drive of 350 watts it will deliver any output from zero to one kilowatt peak. The rated average output of the stage is 600 watts.

### THE VIDEO AMPLIFIER

An interesting feature of the video

*(Continued on page 640)*

By FRED SHUNAMAN

# NOMOGRAPH CONSTRUCTION

## *Part I—Nomograph for Current, Voltage and Resistance*

A NOMOGRAM *(Greek: A new written down)* is a chart made up of a number of lines calibrated to represent quantities in the problems to be solved. A straight edge is laid across two of the lines. The answer to the problem is found where it intersects a third line. Most of the commonest radio problems can be put into nomograph form, hence this type of chart is one of the most useful to radiomen.

This principle of the nomograph is simplicity itself. Fig. 1 shows a typical one, for adding figures from 1 to 10. The outside lines which represent the numbers to be added, may be 10 inches long, divided into equal parts (inches). The totals are found on a line drawn midway between the two.

To calibrate the center line, lay a ruler across the tops and bottoms of the two outside ones. Because 0 plus 0 = 0, the base of the center line is 0. At the top, 10 plus 10 = 20, and the line is so marked. Dividing the center line equally gives us 20 divisions spaced one-half inch apart. If a ruler is now placed across the two 5's on the outside lines, the sum 10 will be read on the center one. Try 5 plus 8 or 9 plus 1.

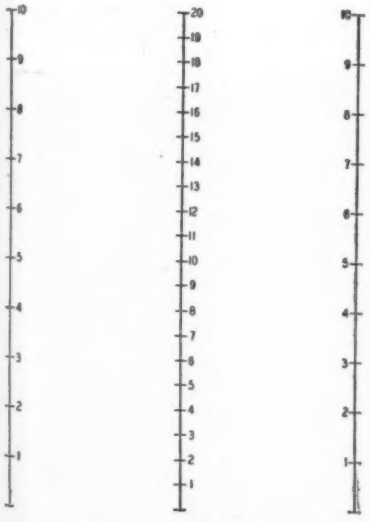


Fig. 1—The fundamental type of nomogram.

The reader will find it very helpful to actually construct such a nomogram. The important point to note is that the center line has twice as many divisions as the two outside ones. That is why their sum is found on it.

The addition nomogram may be mildly interesting. It is hardly useful—it is easier to do the additions mentally than to use the chart. The nomogram becomes valuable when applied to equations like the familiar $f = \frac{1}{6.28\sqrt{LC}}$. Such application is possible because multiplication and division can be transformed into addition and subtraction by means of *logarithms*.

Most radiomen understand logarithms. To those who do not, it is enough to say they are numbers so proportioned to ordinary numbers that the *sum* of the logarithms of any two numbers is equal to the logarithm of their *product*. For example, adding the logarithm of 5 to the logarithm of 6 gives the logarithm of 30. If we construct a chart like that of Fig. 1, using the *logarithms* of numbers from 1 to 10, we have a nomogram that can multiply.

### CONSTRUCTION OF NOMOGRAMS

Nomograms for all radio uses can be constructed with the help of a small supply of logarithmic cross-section paper, which can be bought at almost any stationery or draftsman's supply house. It is well to get a few sheets of "1 cycle × 10 divisions per inch" as well as a smaller number of 2-cycle and 3-cycle sheets (also 10 divisions per inch). Some tracing paper completes the outfit. Lacking logarithmic paper, a cheap slide-rule may be pressed into service. (The slide-rule is a perfect example of a logarithmically divided scale.)

Simplest of all multiplication nomograms is the product of two whole numbers—the logarithmic equivalent of Fig. 1. A chart for the common radio equation IR = E (Ohm's Law) is set up in Fig. 2. The easiest way to construct it is to fasten a piece of tracing paper over one of the 1-cycle log sheets and trace each of its vertical border lines. You will then have two lines about 10 inches high and 7 inches apart. Draw the base-line and erect on it a vertical center line half-way between the other two. Number your two outside lines according to the scale beneath the tracing paper. Mark the two outside lines I and R, and the center line E. (I × R = E).

Next step is to calibrate the center line. The bottom number on each outside scale is 1. Therefore the center scale at the base line is 1 × 1 = 1. The top of the center line is 10 × 10, or 100. Insert a 2-cycle sheet under the tracing paper, and line the base lines up with each other. You will find the 1 and 100 in the correct positions, and can fill in the other divisions by tracing.

With this chart, the current through or voltage across any resistor between 1 to 10 ohms or 1 to 10 amperes and 1 to 100 volts can be calibrated.

### A PRACTICAL CHART

Our nomogram still seems to be of little use—the range is altogether too limited, and these simple problems are easier done in the head. It is not altogether useless, though its main purpose is to show how a nomogram works, before introducing more complicated ones. Its range can be extended by multiplying or dividing either of the factors I or R by any number (most conveniently 10) and doing the same with the center scale. Or one outside scale can be multiplied by and the other divided by the same number, leaving the center scale unchanged.

One of the great advantages of the nomograph is direct reading, so such tricks are not worth while. We can make a satisfactory chart by extending the two outside scales. Let us make one with the I and R scales on 2-cycle paper,

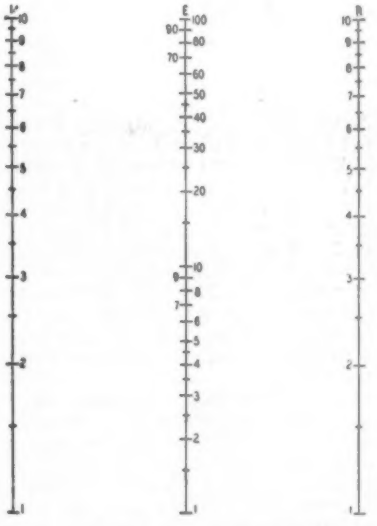


Fig. 2—Most nomograms are forms of this one.

giving them a range of 100 to 1 instead of 10 to 1. We can further increase the range by using two sets of figures for each I and R scale, giving us in effect two nomograms on the same sheet of paper.

*(Continued on page 629)*

By J. C. HOADLEY

# BETTER BROADCAST TUNER

## *Companion to the Hi-Fi Amplifier Described in April*

FOR persons who live within forty miles or so of a broadcasting station a TRF tuner is entirely adequate and has some advantages, particularly in large metropolitan areas where there are more than three stations. For high-fidelity reception, it is essential that our tuner not cut sidebands, or, that is, not have too high selectivity. As the standard AM broadcast stations generally operate so as to limit their band width to 10 kilocycles, it is necessary to provide a tuner with a response characteristic which has a flat top ten kilocycles wide. This can be done well with a superheterodyne, but

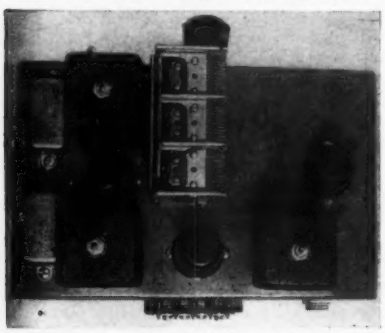


Photo A—Top view of the high-fidelity tuner.

requires special intermediate frequency transformers and a complex circuit. A simple three-tube tuned radio frequency receiver can be built with a reasonably flat 10-kilocycle band width for a small fraction of the cost of the super. The TRF tuner will have a lower noise level, as it contains less tubes. It is also much easier to align. All that is necessary is to have a screwdriver and a station. The heart of this tuner is the coils. They should be of the shielded type.

Iron-core coils have the advantage of being tunable, so that the inductance of the coil may be varied to suit the particular variable condenser that you have.

The condenser is a three-gang unit, and should have trimmer condensers mounted on it. If not, three auxiliary compression-type condensers that have a capacity of about 70 micromicrofarads should be provided. All else we need are three octal tube sockets, a few resistors and condensers and a chassis. The chassis may be bent from steel or aluminum.

The layout shown in Photos A and B worked out very well. However, it can be changed somewhat if the shape of your chassis is different. The important thing is to keep the grid leads from the tube to the condenser and coil, short, and as far away from the other grid leads as possible, or oscillation will result. These leads should also be kept close to the chassis, to keep down stray coupling. The parts in the author's model were mounted on a resistor board, which makes for a very neat arrangement.

A simple resistor board can be made of a piece of bakelite, cut in an oblong shape as in Photo C. Holes are drilled and soldering lugs are bolted to the bakelite. Resistors are soldered between the lugs. Of course, the resistors can be hung on the tube socket pins if a resistor board is not used. A terminal strip is provided on the back for connection to a power source. It is assumed that any standard amplifier will stand the additional current drain, which is very light, being in the order of 25 milliamperes. If the amplifier does not have a 6.3-volt filament supply, or if it is heavily loaded, a 1½-ampere 6.3-volt transformer may be mounted on the tuner. Note that the output is taken from a microphone connector and should be run through shielded mike cable to the amplifier.

An audio volume control was not included as it is assumed that the builder's amplifier will have one. If one is used it would be connected as in Fig. 2. The circuit diagram is shown in Fig. 1. It will be noted that resistors are connected across the coils. This is to increase the band width by reducing the Q of the coils and making their tuning broader. An r.f. gain control is provided as a sensitivity control. It has several functions. First, it allows the tuner sensitivity to be reduced when receiving a powerful local signal, which might overload the first tube's grid and cause

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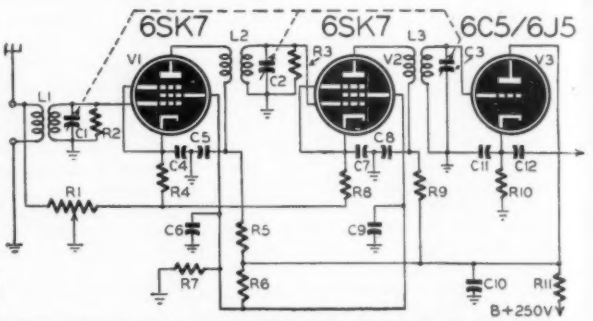


Fig. 1—The tuner is a 3-tube TRF with infinite-impedance detector.

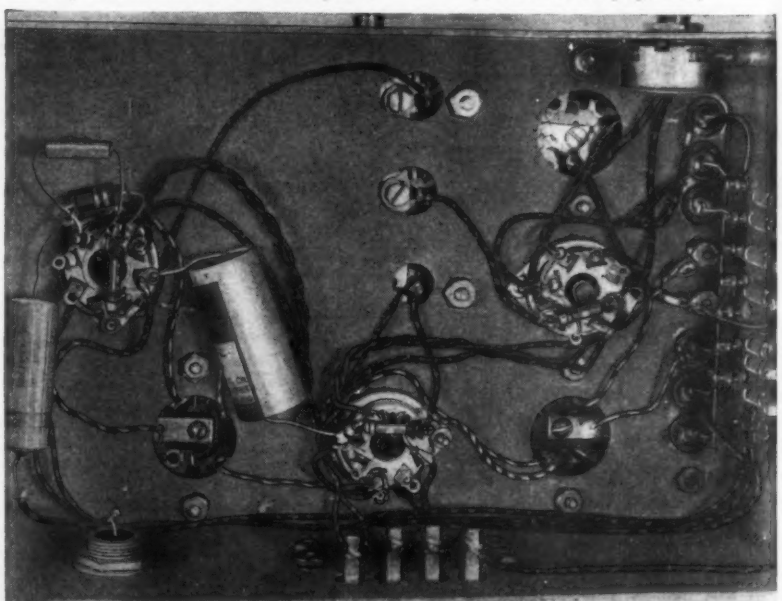

Photo B—Under-chassis wiring is simple and appearance is improved by the resistor board.

By ROBERT F. SCOTT

# "PORTARIG" HAM STATION

## *A Versatile Transmitter-Receiver for the Amateur*

WHILE a member of the armed forces, in the early days of the war, the writer was detailed to design and construct a transmitter and receiver to be operated in a "jeep" and powered by a six-volt vehicular storage battery.

The specifications for the transmitter and receiver, listed below, were very liberal and left much to the judgment and ingenuity of the builder:

**Transmitter**

Type of emission.....A1 and A3
Output circuit.....Any single wire antenna
Power input.....30 watts, phone/cw
Frequency control.....Optional
Primary power.....6-volt vehicular battery
Size.....As compact as possible

**Receiver**

Type.....Non - radiating
Type of reception.....A1 and A3
Frequency range.....Same as transmitter
Frequency control.....Optional
Primary power.....Same as transmitter
Size.....As compact as possible

The transmitter and receiver to use as many tubes of the same type as possible to simplify the replacement problem. Both to have a minimum number of controls and be practically fool-proof.

Upon seeing the specifications, the writer saw a perfect chance to develop that "dream" portable amateur station. It would even be possible to test and prove the station by operating on the 40- and 80-meter bands.

The original designs called for variable frequency oscillators, to be operated from a single control, in receiver and transmitter. This proved unreliable because of the drift of the two oscillators. In many instances they would drift in opposite directions and there was no practical method of keeping them synchronized. The next step was to resort to crystal control for both units. This method proved to be the ideal solution to the problem.

One of the principal features of this set is the ease and speed with which the frequencies may be changed. Four preset crystal-controlled channels are provided for the receiver and transmitter and any one of these may be selected at the turn of a switch.

Since continuous tuning is not used; the tuning elements of the receiver and transmitter are mounted on a removable tuning unit which may be replaced with one covering a different range of channels. The channels covered by each tuning unit are spaced 200 kc apart.

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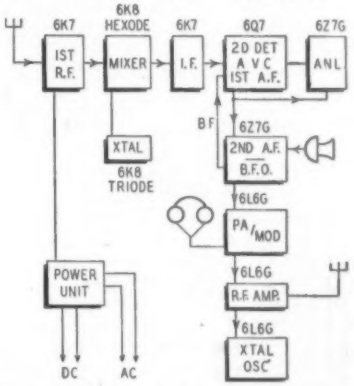


Fig. 1—Block diagram of complete apparatus.

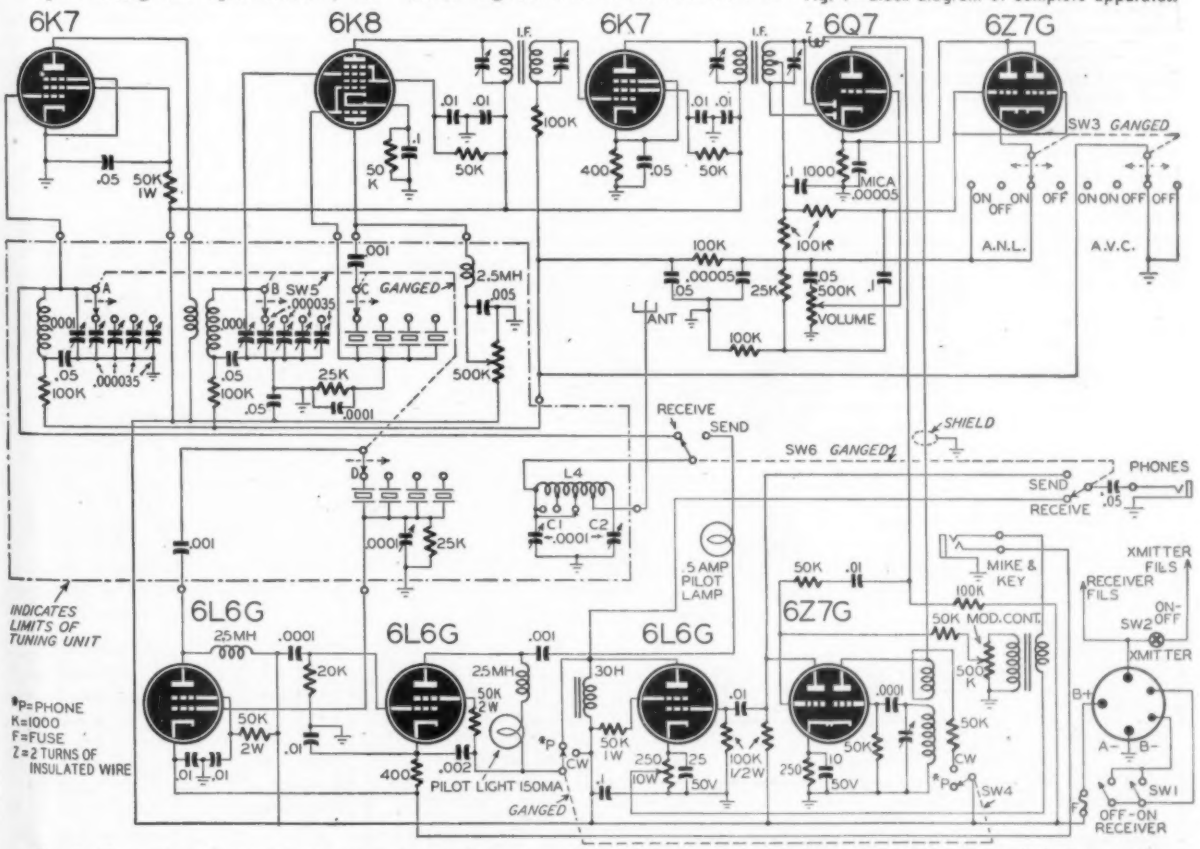


Fig. 2—The equipment consists of a transmitter and receiver adapted to work on several bands and on a.c. or 6-volt battery supply.

The average distance covered by this station is 30 miles when amplitude modulated and operated from a moving vehicle equipped with a 15-foot whip antenna. The range is more than doubled when using c. w. Under proper conditions, several hundred miles may be covered when operating from a fixed position with a quarter-wave antenna. These figures were determined when operating on frequencies between 3 and 4 mc.

The block diagram, Fig. 1, shows the relationship between the various parts of the transmitter and receiver.

## THE CIRCUITS

The receiver uses a 6K7 r.f. amplifier, 6K8 crystal oscillator-mixer, 6K7 i.f. amplifier, 6Q7 second detector, a.v.c. and first audio amplifier, 6Z7 a.n.l. (automatic noise limiter), 6Z7 b.f.o. and second audio amplifier, and a 6L6 power amplifier. (See Fig. 2.)

The transmitter r.f. section uses a 6L6 in a Pierce oscillator circuit driving a 6L6-G power amplifier. The modulator of the transmitter uses a part of the receiver audio section. One section of the 6Z7 is the speech amplifier, driven by a single-button carbon mike, and drives the 6L6 as a modulator.

With the SEND-RECEIVE switch in the receive position, the antenna is connected to the grid circuit of the r.f. amplifier. The signal is amplified and fed to the hexode section of the 6K8. At this point, the input signal is mixed with the output of the crystal oscillator in the triode section of the tube. The 456-kc i.f. thus produced is amplified by the 6K7 i.f. amplifier and applied to the diodes of the 6R7. The diode load resistor is tapped to provide a.v.c. and a.f. voltages. The a.f. voltage is amplified by the triode section of the 6Q7 and passed on to the grid of the second a.f. amplifier (one section of a 6Z7-G) by resistance coupling. The output of the 6Z7-G drives the 6L6, which has a 30-henry choke as its plate load. Headphones or speaker are connected to the 6L6 plate through a blocking condenser.

A portion of the rectified voltage of the second detector is applied to a 6N7 connected in a Dickert automatic noise limiter circuit. The switch for this circuit is combined with the a.v.c. switch to provide selective operation of either or both circuits.

When the PHONE-CW switch is in the cw position, plate voltage is applied to the b.f.o triode of the second-audio-b.f.o. tube. The output of this oscillator is loosely coupled to the diodes of the 6Q7. A second section of this switch removes the modulation choke from the plate lead of the power amplifier.

The combined power requirements of the transmitter and receiver totalled over 170 ma at 350 volts. A vibrator type power supply was selected for this service because it is compact and more easily serviced during field operation than the dynamotor or genemotor types.

To satisfy the comparatively large current requirements, two "universal" power transformers were selected. These units are equipped with two primary windings, one of which operates from a six-volt battery through a vibrator; the other operates from a 117-volt a.c. line. Each of the transformers was wired with individual vibrators in the six-volt primary winding. The high-voltage output from the transformers is rectified by separate full-wave rectifiers and fed into a common condenser-input filter circuit. The heavy current drain made it necessary to use two 6X5 rectifier tubes with plates connected in parallel in each of the high voltage circuits. When connected as in Fig. 3, the unit supplies more than 250 ma at 350 volts.

Since the 117-volt a.c. winding was available, it was decided to adapt the set so that it could be operated from line voltages if the occasion demanded. During a.c. operation, it is necessary to remove the vibrators from the circuit to prevent possibility of being damaged. Switching from a.c. to d.c. is accomplished by using two separate power cords which terminate in 12-contact sockets. A 12-contact panel-mounting male plug is mounted on the chassis of the power unit. The sockets and plug are wired so that the tube filaments are connected across the d.c. line when battery power is being used. When the set is being operated from 117-volt a.c. supplies, the a.c. socket is connected to the plug and the vibrator leads are opened so that no a.c. will circulate through the vibrators. The a.c.-socket also switches the tube filaments so that they operate from the transformer filament windings.

A five-prong tube socket is mounted

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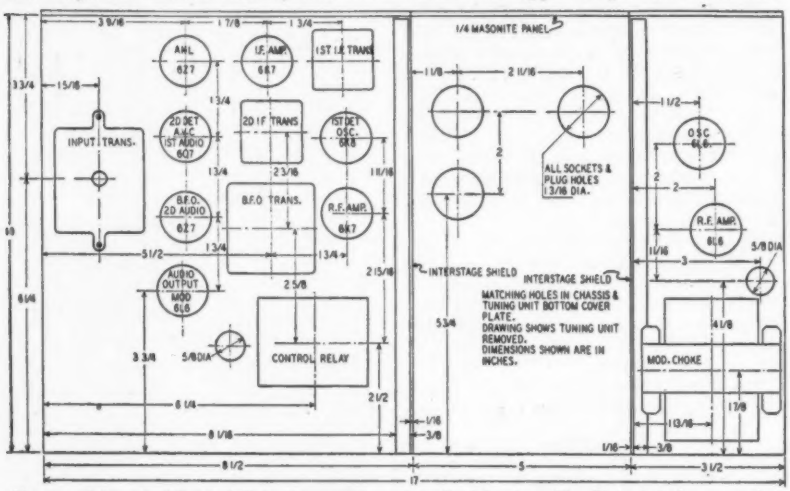



The panel layout. "Control Relay" was not used in final hookup. The 5/8-inch holes were for leads from available top-mounted components and may not be needed for different parts.

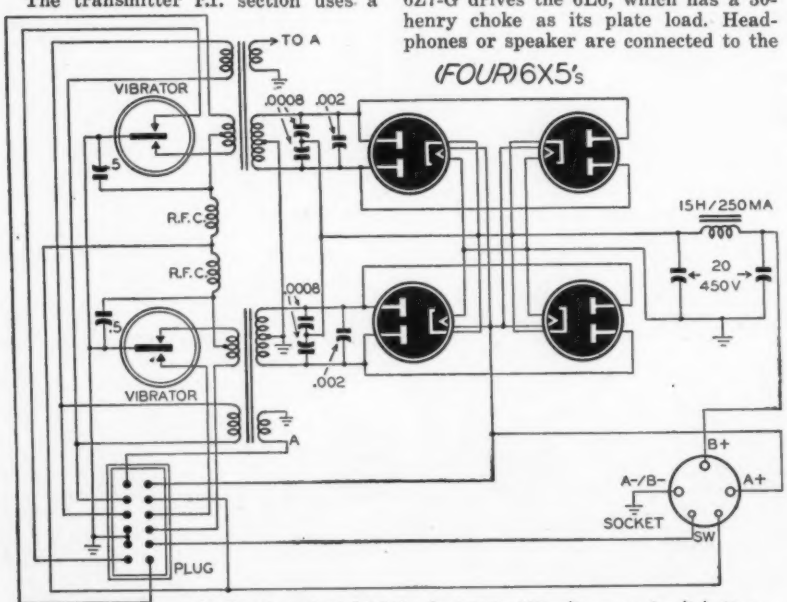
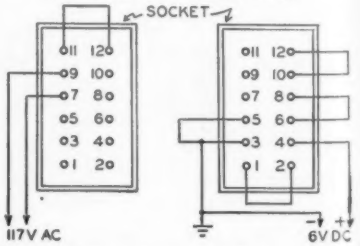



Fig. 3—Power supply. Shorting plugs (right) adapt it to 117-volt a.c. or 6-volt battery.



By JORDAN McQUAY

# VIDEO AMPLIFICATION

## *Apparatus Which Works From 30 Cycles to 4 Megacycles*

COMPLEX wave shapes encountered in radar, television, and some industrial electronic circuits have a very high order of harmonic content[1]. These signals contain a wide range of frequency components—often from 30 cycles up to 4 megacycles. Amplification of such a wide band of frequencies can only be accomplished by the circuit known as a *video amplifier*.

Chief difference between a video amplifier and an ordinary audio amplifier, is that the video amplifier (Fig. 1) provides nearly constant gain over an exceptionally wide range of frequencies *which include and far exceed the audio frequency band*. Thus, a video amplifier might be considered an extremely high fidelity audio-frequency amplifier. A comparison of the frequency response of the two amplifier types is shown in Fig. 2.

If all of the harmonic component of a complex wave does not receive the

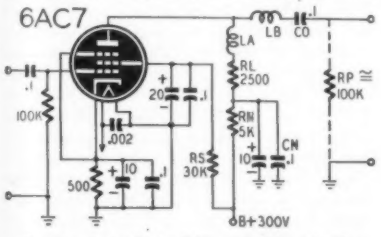



Fig. 1—A typical video amplifier circuit.

same degree of amplification, the wave shape is altered and distorted. This condition of unequal gain is known as *frequency distortion*.

If the phase delay is not constant, further distortion is introduced into the original wave shape. This is known as *phase distortion*.

1—See "Electronic Transients," *Radio-Craft*, February, 1946.

Ideal video amplifiers must be entirely free from both types of distortion. This is particularly true of phase distortion—the more serious—since it would result in reproduced pulses and wave shapes bearing little resemblance to the original.

However, through careful design and construction of video amplifiers it is possible to obtain and preserve a relatively flat gain response—so that all sine-wave components within the desired video range are transmitted without frequency distortion and without phase distortion.

This characteristic requirement of all video amplifiers is accomplished first, by sacrificing the *amount* of amplification per stage in favor of fidelity, and second, by using specially compensated resistance-coupled circuits.

### CIRCUIT ELEMENTS

Because of the wide range of frequencies involved in video amplification, it is impossible to employ either transformer coupling or impedance coupling. Use of resistance-capacitive coupling, however, presents a number of circuit problems which must be overcome.

These problems can best be understood through study of an ordinary audio amplifier.

In such a conventional circuit (Fig. 3), the high frequency response is limited by various inherent circuit capacities. $C_T$ represents the plate-to-cathode capacity of the tube, capacities due to the physical location of wires and circuit elements, and distributed capacities of the plate circuit. $C_P$ represents the combined input and wiring capacities of the following video stage or device. Both $C_T$ and $C_P$ act in parallel, and shunt the load resistance $R_L$ of the tube in the following manner.

At low frequencies, $C_T$ and $C_P$ have very little effect on circuit operation, because their reactance is large compared with the load resistance and the input resistance $R_P$ of the following stage or device. But at very high frequencies their capacitive reactance becomes so small that these capacities behave very much like short circuits across the load resistor $R_L$ and the input resistance $R_P$, respectively.

Thus it is necessary to modify con-

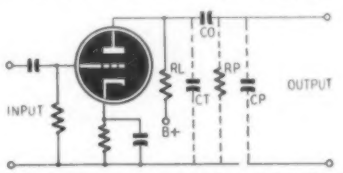



Fig. 3—Unseen components in a tube circuit.

siderably the amplifier circuit shown in Fig. 3 to adapt it for wide-band amplification.

First modification concerns a different type of vacuum tube.

The best tube for a video amplifier is one having small inter-electrode capacities *combined* with a large value of grid-to-plate transconductance ($g_m$). Such characteristics assist directly in limiting or neutralizing *some* of the undesirable circuit capacities mentioned previously.

Some triodes are useful as video amplifiers. Much more preferable are pentodes and tetrodes having a high value of transconductance. Of this kind is the 6AC7/1852, the 6AG7, 6SH7, and 6SJ7. Other tubes suitable for wideband operation are the types 6AB7, 6AG5, 807, 6Y6G, 6V6, 25L6, 1231, and 1232.

The recently developed orbital-beam secondary-electron multiplier can also be used as a video amplifier. It can be used over a very wide band.

The insertion of a high $g_m$ pentode in the original triode amplifier (Fig. 3)

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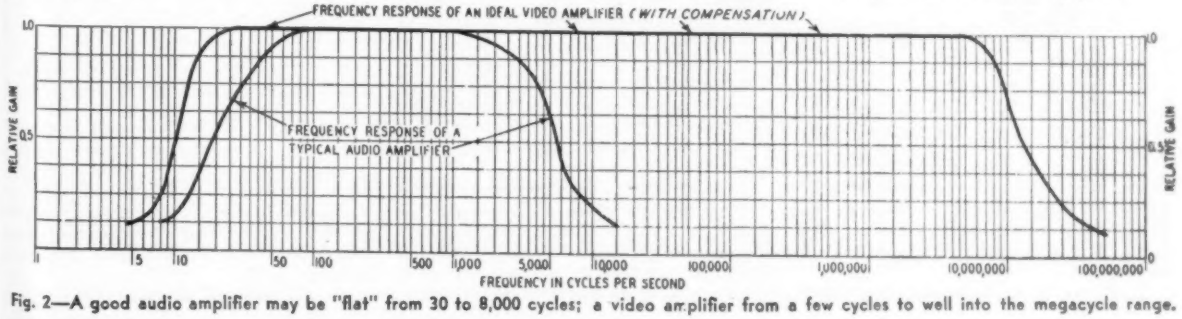


Fig. 2—A good audio amplifier may be "flat" from 30 to 8,000 cycles; a video amplifier from a few cycles to well into the megacycle range.

now results in the basic video amplifier circuit shown in Fig. 4. Although the inter-electrode tube capacities have been decreased by use of a pentode, the problem of distributed, reflected, and other circuit capacities must still be overcome. Further modification is necessary.

Such modification is known as *resonance compensation*, and chiefly concerns the extreme limits of high-frequency and low-frequency response of the amplifier.

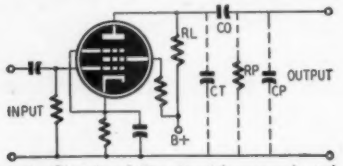

Fig. 4—Circuit of Fig. 3 with pentode tube.

Compensation methods which are effective at high frequencies produce little or no change in the low-frequency response, and *vice versa*. Therefore, the two problems can be considered separately.

## HIGH-FREQUENCY COMPENSATION

Principal cause of gain decrease at the high frequencies is reduction of the plate load impedance due to the shunting effects of circuit capacities ($C_T$, $C_P$), (Fig. 4).

The upper frequency limit can be extended considerably—and the general high-frequency response greatly improved—if the effective impedance of the pentode and wiring capacity is *increased* at the higher frequencies of operation.

One method of increasing the reactance of a capacitive circuit is by creating a condition of parallel resonance. This, of course, will produce the greatest impedance at the resonant frequency of the parallel circuit. But if the Q of such a circuit is low, the resonance peak will be flattened out. If values of the resonant circuit are chosen so that the flat "peak" occurs in the region where normal gain of the amplifier begins to diminish, the mid-frequency or flat-gain response can be extended considerably into the high-frequency region.

For this purpose a small inductance $L_a$ is inserted in series with the load resistor $R_L$, as shown in Fig. 5.

Value of the coil $L_a$ is from 50 to 100 microhenrys. Value of the load resistance should be from 1000 to 4000 ohms.

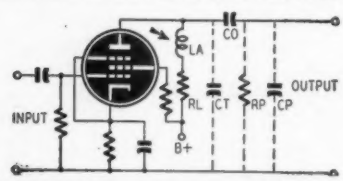

Fig. 5—High-frequency compensation circuit.

The parallel resonant frequency ($L_a$ across the various tube and circuit capacities) is roughly the same as the upper limit of amplifier operation. This upper frequency limit rarely exceeds 3 megacycles.

This type of high-frequency compensation is known as *shunt peaking*, since the coil is connected *across* the circuit.

Another method of high-frequency compensation is known as *series peaking* (Fig. 6).

In this instance, a small inductance $L_b$ is inserted in series with the coupling condenser $C_o$. At the desired upper frequency limit of operation, the inductance resonates with the input capacitance $C_P$ of the next video stage or device.

Increased current flow through $C_P$ in turn causes an increased voltage across this capacity, resulting in higher gain and less phase shift than possible with the preceding means of compensation.

This method has a further advantage over the shunt peaking system, since the inductance $L_b$ isolates the effects of the output and input capacities $C_T$ and $C_P$.

Gain response will be substantially

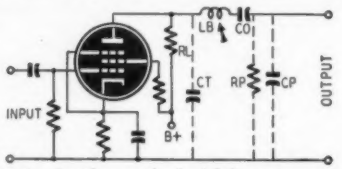

Fig. 6—Another method of h.f. compensation.

flat over the high-frequency region, comparable to mid-frequency response. And the upper limit of amplifier operation is approximately the same as the resonant frequency of the series peaking circuit.

A third method of high-frequency compensation combines the features of both shunt and series peaking. Resultant circuit (Fig. 7) gives the high-frequency extension of the shunt peaking method as well as the increased gain caused by the resonant effect of the series peaking method.

## LOW-FREQUENCY COMPENSATION

The low-frequency response of an amplifier is influenced primarily by the

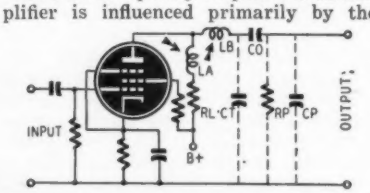

Fig 7—Both compensation methods combined.

grid-coupling condenser $C_o$ and the effective input resistance $R_P$ of the following stage or device. As the frequency of operation decreases, the reactance of condenser $C_o$ increases. And at frequencies less than about 200 cycles, this reactance causes a strong attenuation of the signal wave.

To maintain constant amplitude and a minimum of phase shift at low frequencies of operation, a compensating filter—resistor $R_N$ and condenser $C_N$—is inserted in series with the load resistor $R_L$ (Fig. 8).

As the operating frequency is decreased, the reactance of $C_N$ increases—causing the $R_N C_N$ combination to function as an *additional* load resistance. This action tends to increase the gain inversely (and at the same rate) as the coupling condenser $C_o$ tends to reduce the gain.

The compensating filter also introduces a phase displacement in the plate circuit that compensates for the phase shift caused by the coupling circuit $C_oR_L$.

Low-frequency compensation may also

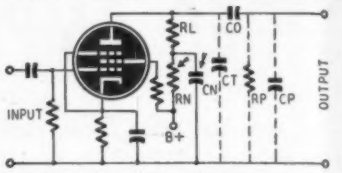

Fig. 8—Extending the low-frequency response.

be provided by a filter unit arranged in parallel with the coupling condenser $C_o$, as shown in Fig. 9. The resistor $R_N$ compensates for low-frequency losses, since $C_o$ is paralleled by the reactance of the filter condenser $C_N$.

Either method of low-frequency compensation may now be combined with one of the high-frequency compensation methods previously discussed, to provide a flat-gain response characteristic over a very wide range of frequencies. A typical circuit having both high- and low-frequency compensation is shown in Fig. 1, and its response curve in Fig. 2.

## OTHER CONSIDERATIONS

There are other important circuit considerations in the design and construction of video amplifiers.

Parts and components must be arranged physically so that leads are as short as possible and properly spaced to minimize distributed capacitance between wires. Coupling condensers should be remote from other circuit elements, and *all* condensers should be mounted close to tube sockets, whenever possible.

For effective by-passing over the entire band of frequencies, electrolytic condensers shunted by small paper condensers are generally used. Cathode bypass condensers must be extremely large to prevent any feed-back of cathode current at the very low frequencies of operation.

Necessary grid bias is usually obtained by utilizing the voltage drop across a resistor in series with the cathode. Variations caused by the input

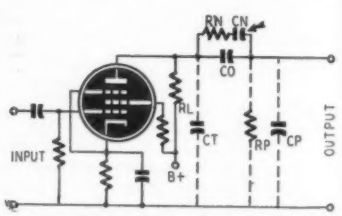

Fig. 9—Another compensation circuit for l.f.

signal are by-passed around the bias resistor by means of condensers. Time constant of the cathode resistance and capacitance should be long compared to the period of the lowest frequency to be passed. Value of the electrolytic condenser should be no less than 10 microfarads.

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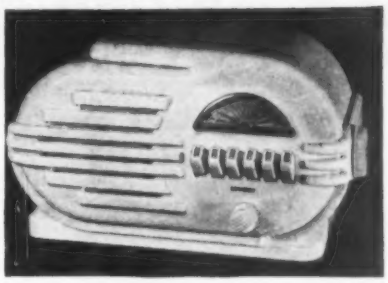
# RADIO DATA SHEET 336

## BELMONT RADIO

### MODEL 6D111, Series A



Tuning range.....530 to 1650 kc.
I.F. .....455 kc.
Power consumption.....35 watts
Sensitivity (for 0.05 watt output).....10 microvolts average

Selectivity ..55 kc broad at 1000 x signal at 1000 kc
Maximum power output .....1.0 watt
Undistorted power output ...0.8 watt
Voice coil impedance.....3.2 ohms

### ALIGNMENT PROCEDURE

- No aligning adjustments should be attempted until all other possible causes of trouble have been thoroughly checked.
- Chassis must be removed from cabinet for proper alignment. Slight adjustments of the oscillator and antenna circuits can be made, without removing the chassis, through two holes provided on the bottom of the cabinet. The two adjustment screws can be reached with a long insulated screwdriver.
- It is important that during alignment the loop antenna be maintained at the same distance from the chassis as when the chassis is installed in the cabinet.
- Turn volume control to maximum for all adjustments.
- Connect ground post of signal generator to B- of radio through a 0.1 μf condenser.
- Connect dummy antenna value in series with generator output lead.
- Connect output meter across primary of output transformer.

| Band | Signal Generator Frequency Setting | Dummy Antenna | Connection to Radio | Tuning Condenser Setting | Adjust for Maximum Output |
|---|---|---|---|---|---|
| I.F. | 455 kc | 0.1 μf | Grid of 12SA7 | Rotor full open (plates out of mesh) | 4 trimmers on input and output i.f. transformers |
| Broadcast | 1650 kc | 0.1 μf | Grid of 12SA7 | Rotor full open (plates out of mesh) | Oscillator trimmer C7 on bottom of radio |
| | 1400 kc | None | See note A | Set dial at 1400 kc | Antenna trimmer C2 on bottom of radio |

Note A: Lay output lead of generator in back of loop antenna. Turn up generator output. Loop antenna will pick up energy.

### REPLACING DIAL POINTER DRIVE CORD

Six inches of cord are required in the set. Use a piece slightly longer so that knots may be tied at each end.

Rotate tuning knob to extreme clockwise position. This closes tuning condenser. Knob should remain in this position until installation is completed.

Tie knot at one end of cord and place it in key washer. Wind cord one turn around shaft.

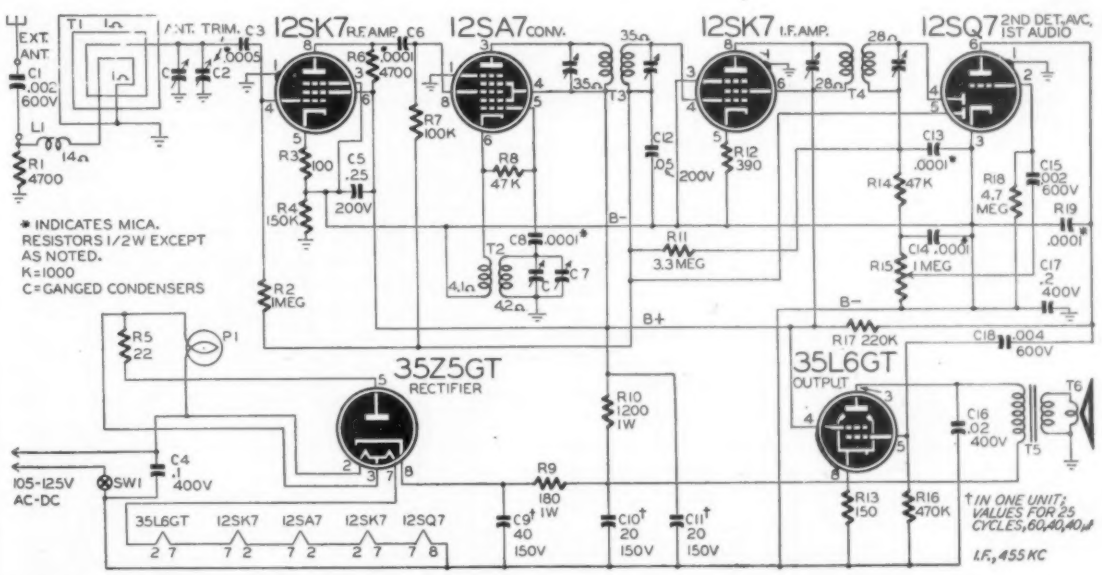
Pass cord over idler pulley.

Pass cord over pointer shaft; wind it one turn around shaft; pass it through key washer; wind it one more turn around shaft.

Hook spring over end of dial support. Tie cord to spring. IMPORTANT: Before tying knot stretch spring enough so that full contraction of spring will rotate pointer shaft at least one-half turn.

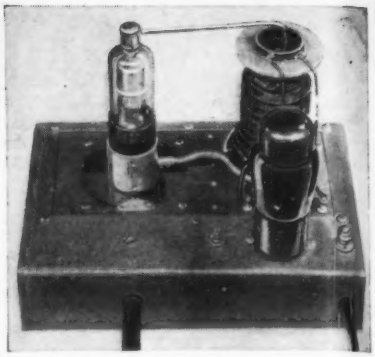
Remove dial crystal by removing Cinch buttons.

Make sure tuning knob is in extreme clockwise position. Then rotate pointer clockwise, against friction of shaft, until it is in horizontal position.



By NATHANIEL RHITA

# R.F. POWER SUPPLIES



Appearance of the commercial r.f. power unit.

THE power supply has long been a headache in the design and operation of high-voltage, low-current apparatus. The necessary iron-core transformers are bulky, heavy and expensive. They are also inefficient in these circuits because the relatively high current available from them cannot be used. Television kinescopes and electron microscopes require, in general, less than one milliampere. High-voltage insulation between windings makes the transformer very expensive.

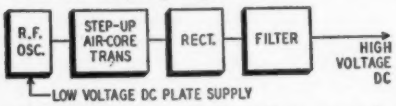



Fig. 1—Components of high-voltage r.f. pack.

A radio-frequency circuit eliminates the main disadvantage—the iron-core transformer supply. An r.f. oscillator is operated at a high radio frequency. The output is stepped up (in an air-core transformer), rectified and filtered to give the high d.c. voltage at low values of current. The results:

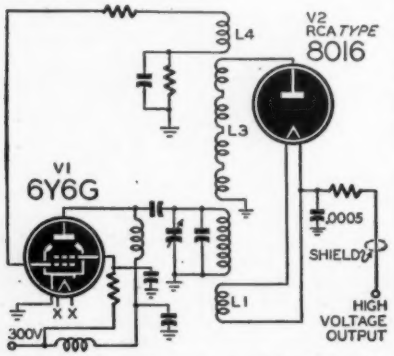



Fig. 2—The unit uses a receiving-type tube.

1. *Compactness.* The large iron-core transformer and filtering components are eliminated.

2. *Light weight.* The heavy iron core which made up most of the weight of the power supply is no longer required. Small filter condensers are sufficient.

3. *Safety.* The output current from the circuit is definitely limited even under short-circuit condition. A filter condenser of about 500 μμf can hold only a relatively small quantity of electricity. This reduces the danger of shock or injury.

4. *Economy.* Elimination of the large and expensive iron-core transformer and reduction in size of filter components permit a substantial reduction in cost.

A block diagram of the power supply is given in Fig. 1. The oscillator can be a receiving-type tube since the output power required is small. Because of the high frequency and small current, filtering is simple.

A recently announced commercial type of television power supply* is illustrated in the photograph and schematic (Fig. 2). Note the compactness and simplicity of design. A beam power 6Y6G is used as oscillator, an RCA 8016 as rectifier. The latter tube filament requires only ¼ watt, easily supplied from a fractional turn of wire on the high-voltage transformer. The unit is definitely portable and can be placed anywhere without danger of supply-line-frequency pickup by other circuits.

Figs. 3 and 4 give performance data of this supply. The voltage regulation is 15% from no load to 800 microamperes drain. The frequency characteristic is not critical, optimum being obtained at about 300 kc. This model is adapted to operate up to 14-inch direct-viewing kinescopes and similar tubes, and is available either with or without the d.c. oscillator power supply. The earlier types have an adjustable output of from 6000 to 10,000 volts.

A higher voltage model for the projection type kinescopes is also available. Due to a voltage-tripling circuit, the output is 30,000 volts.

Design considerations in this type of supply are

(a) eddy current loss
(b) voltage insulation
(c) resonance curve
(d) voltage regulation

Note the use of a pie-wound transformer secondary to guard against voltage breakdown. The coefficient of coupling between primary and secondary determines the double-humped shape of resonance curve and voltage regulation.

The advantages of a well-designed r.f. oscillator-rectifier combination make it an ideal source of supply for oscilloscopes or other cathode-ray tube applications, as voltage is usually high and current low. The suitcase-type electron microscope owes much of its portability to the use of such a power supply.

Although r.f. power supplies have not come into common use, they are by no means entirely novel. Design and operation of such a unit was described by O.H. Schade, of the Radio Corporation of America, in a paper pub-

(Continued on page 647)

* U. S. Television, New York City.

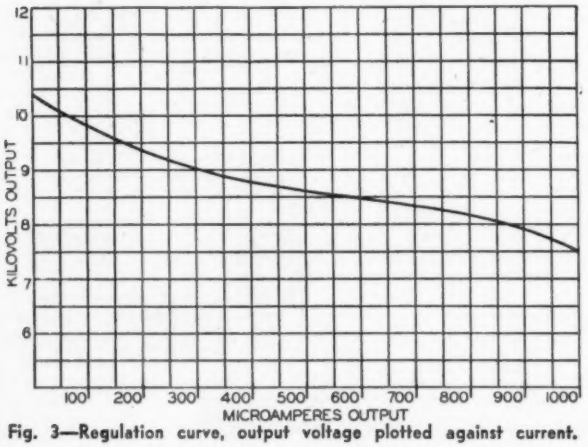



Fig. 3—Regulation curve, output voltage plotted against current.

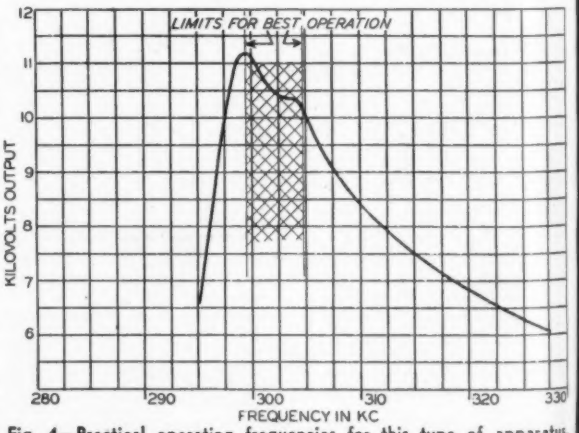



Fig. 4—Practical operating frequencies for this type of apparatus.

By ARTHUR HOWARD & MORRIS EDDY

# MATHEMATICS—RADIO TOOL

## *Part I—Some Problems of Receiver Design and Operation*

WHENEVER the word "mathematics" is uttered in radio circles, not too infrequently the novice and radio veteran are alike gripped by fear. They imagine the subject to be dull, abstract, and very difficult; something to be avoided at all costs! The appalling situation can be attributed, in no small measure, to the poor pedagogical methods in our schools.

All sciences owe a great deal to mathematics for their development. This is particularly true of radio and electronics. We deal with substances and terms which are completely insensible to the human organs and alien to our imagination. We try to understand them by meager analogies; electricity depicted, for example, as flowing water. To fully comprehend the principles and enable us to solve many practical problems in radio work, mathematics is a vital necessity. In the following, we present a number of radio problems and their solutions. They are designed to illustrate how important a tool mathematics can be to the radioman. Only simple arithmetic will be assumed on the reader's part, ordinary common sense being the most important factor in understanding the following.

### THE CATHODE BIAS RESISTOR

A very frequent problem is the determination of the cathode resistance value of a vacuum tube. For example, what value resistor is required for a 6C5 triode operating as a class A amplifier, with a plate voltage of 250 volts? (Fig. 1).

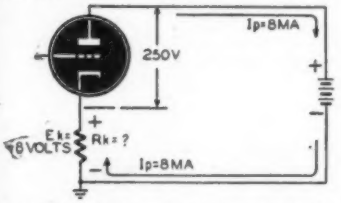



Fig. 1—Calculation of tube's cathode bias.

Turning to the tube manual, we find the grid-bias voltage to be −8 volts and the plate current, 8 milliamperes. Using Ohm's Law and some arithmetic, we solve the problem.

The formula—

$$R_k = \frac{E_k}{I_p} \times 1{,}000$$

Where $R_k$ = resistance value of grid-bias resistor in ohms, $E_k$ = grid-bias voltage in volts, and $I_p$ = plate current in milliamperes.

Substituting the known values in the formula, we have—

$$R_k = \frac{E_k}{I_p} \times 1{,}000 = \frac{8}{8} \times 1{,}000$$

$$= 1{,}000 \text{ ohms}$$

Where tetrodes or pentodes are employed, we follow the same method as above in obtaining the solution, with the added necessity of taking the screen current into account. This is shown in the new formula—

$$R_k = \frac{E_k}{I_p + I_s} \times 1{,}000$$

where $I_s$, the new factor, is the screen current in milliamperes.

What should the wattage rating of the resistor be? Again, mathematics will supply us with the answer.

Using the formula: $W = E_k I_p$

Where W = rating of resistor in watts, $E_k$ = grid-bias voltage in volts, and $I_p$ = plate current in *amperes*.

Substituting the known numbers in the formula—

$W = E_k I_p = 8 \times 0.008 = 0.064$ *watts*

Since there is no resistor available rated at 0.064 watts, we would use a ¼-watt resistor. Commonly, the wattage rating of a resistor is at least twice the calculated value, so a ½-watt resistor would be the smallest practical one, which would include the 100 percent safety factor.

### LINE-CORD RESISTORS

The replacement of a line-cord resistor is a task the radio-serviceman is often called upon to perform. In this case, to solve the problem, his tool is not the conventional ohmmeter, but arithmetic.

Let us assume a five-tube a.c.-d.c. superhet, using a 6SA7, 6SK7, 6SQ7, 25A6, and a 25Z6, is brought in for repair. A continuity test points to an open line-cord resistor. With what value line-cord resistor should it be replaced? (Fig. 2).

From the tube manual, the serviceman finds that each tube draws 0.3 ampere. Then, he notes down the heater voltage of each tube, and adds them up. There are three 6.3-volt and two 25-volt tubes; total, 68.9 volts.

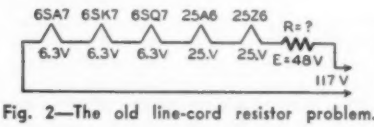



Fig. 2—The old line-cord resistor problem.

In an a.c.-d.c. circuit, the tube filaments are connected in series. Therefore, the same current, 0.3 ampere, will flow through each tube.

Since the line voltage is approximately 117 volts, our problem is to drop (117-68.9), or about 48 volts. Using Ohm's Law—

$$R = \frac{E}{I}$$

Where R = the required resistance in ohms, E = the voltage to be dropped in volts, and I = the current flowing through the tubes, in amperes.

Substituting the known values in the formula, we have—

$$R = \frac{E}{I} = \frac{48}{0.3} = 160 \text{ ohms}$$

Therefore, the line-cord resistor should be 160 ohms. The wattage is found by using the formula $W = EI$, and *doubling* the calculated value.

### VOLTAGE DIVIDER PROBLEMS

In power supplies, a voltage divider is often utilized. It is a tapped resistor connected across the output of the power source, supplying different voltages to the stages of a circuit.

To cite an example, the following voltages and currents are needed.

$E_1$ = 250 volts, 20 ma, $E_2$ = 100 volts, 15 ma, and $E_3$ = 50 volts, 10 ma.

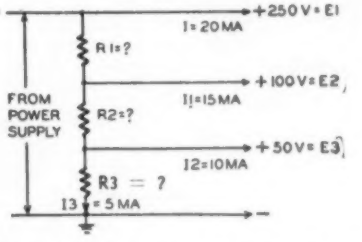



Fig. 3—How to calculate the voltage divider.

The problem is to solve the resistance values between the taps. (Fig. 3). Before we unravel the problem, a current of about 10 percent of total load current, known as the *bleeder* current, must be allowed for. (In this case, the total load current is equal to 20 ma + 15 ma + 10 ma or 45 ma). The bleeder current will then be about 5 ma. Referring to Fig. 3, we proceed as follows:

Let—$I_1$ = 15 ma (the current flowing through the load connected across the 100-volt tap), $I_2$ = 10 ma (the current flowing through the load connected across the 50-volt tap), and $I_3$ = 5 ma (the bleeder current).

*(Continued on page 635)*

By ALFRED SHORTCUT

# ADAPTING A METER

## *Adapting the Superior Channel Analyzer to Wider Uses*

WHILE many people own one of the more expensive signal tracers with a multiplicity of "eyes" or meters, others are not so fortunate. Some may not be able to afford the costlier instruments while others have bought a cheaper instrument at a time when it was available and others weren't. It was in the latter position that the writer found himself a short time ago. The instrument in question was the Superior Channel Analyzer. It was considered good for its cost but not adaptable to all service requirements. The writer set about to find out what could be done to improve it.

First the vacuum tube voltmeter was checked against a standard meter and its accuracy found suitable for service work. Linearity in a positive and negative direction was checked as the meter was to be used with a signal generator to determine FM discriminator characteristics. Linearity was passable over the first half of the scale but not good near the ends, as is to be expected in any instrument utilizing the characteristic of a tube.

The audio section also seemed acceptable. One thing that was desirable was a pair of headphones, since these made it possible to check for distortion in a stage as well as checking gain. While high impedance (preferably crystal) phones are desirable, standard 2,000-ohm phones worked all right provided they were unplugged while making gain measurements. Actually the audio section of a signal tracer is seldom used to measure the gain of a stage but is much more often used to see if the stage is working or causing distortion. So whether the phones are in or out is not of too much importance.

Next we come to the r.f. section of the tracer. Here is where the instrument falls far short of the higher-priced sets. A glance at the circuit, Fig. 1, reveals a single stage of tuned-plate r.f. amplification fed into a diode detector.

This causes poor selectivity and more important, poor sensitivity. The case was taken off to get a look at the insides. By moving some condensers in the rear left hand side (facing the back) of the tracer, room could be made for an extra socket. A second tuned r.f. stage was considered but the idea was abandoned because it would be hard to wind a second set of coils to track with the original ones used. It would be harder still to mount such coils and shield them to prevent regeneration, and a two-gang condenser would be required. While thinking of coils a look was taken at the ones used in the analyzer. They were wound on wooden dowels and due to shrinkage of the dowels the wire was loose. This caused erratic tuning since vibration would move the loose turns. Coil dope was painted on the coil to hold the turns in place.

Since a tuned r.f. stage was not feasible, an untuned stage was considered next. It was necessary to have good amplification up to 18 mc if the entire range of the tracer was to be used. A 6AC7 was chosen as the amplifier because of its high mutual conductance and consequent high gain. To have uniform gain from low frequencies up to 18 mc a plate resistor equal in value to the reactance of the output capacitance of the tube, plus the input capacitance and any stray capacitance, had to be chosen. In addition an inductance theoretically should be placed in series with the plate load resistor. Its reactance should be equal to one half that of the plate load resistor at the highest frequency. If the load resistor alone were used the gain at 18 mc would approximate .707 what it was at medium frequencies. So it was decided to omit the inductance, partly because coil winding is tedious but mostly because of the increased danger of regeneration and the fact that in most service work one is not interested in having an instrument absolutely flat up to 18 mc.

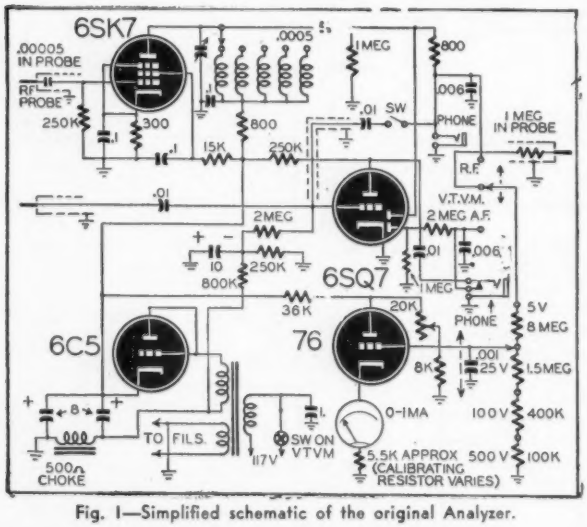



Fig. 1—Simplified schematic of the original Analyzer.

Fig. 1 shows the original circuit of the unit while Fig. 2 shows the modification. The circuit is self-explanatory except for some details. To prevent coupling and feedback between the 6AC7 and the 6K7 it was necessary to shield the wire from the r.f. input to the grid of the 6AC7. A large-diameter shield should be used if possible. It was also necessary to turn the low-frequency coil

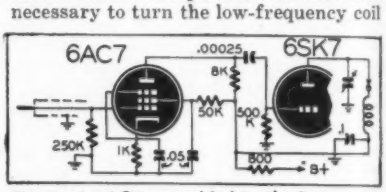



Fig. 2—A 6AC7 was added to the instrument.

90° from its original position and dress the 6AC7 plate load resistor and coupling condenser to the 6K7 away from the coil system. Other units may require even more care to prevent feedback but a little horse sense and judicious cut-and-try should cure it.

Once the extra tube had been added a longer ground wire was installed and the r.f., a.f., and v.t.v.m. cables replaced with longer shielded insulated wire. Instead of the cable end used on the original r.f. probe a phono needle test probe was used. The original probe had a built-in .0005 mf condenser so that connecting the probe to a tuned circuit would not cause serious detuning. Without this condenser touching a tuned circuit would detune it. However in most cases the gain of the tracer is high enough that touching the circuit is not necessary. Merely touching the probe to the insulation on a signal-carrying wire will pick up enough signal to operate the meter. The advantage gained by omitting the condenser is that in circuits where the cable capacity is unimportant it is possible to touch the probe directly to the circuit and trace a much weaker signal. Thus, with the use of the extra tube and the omission of the .0005 mf condenser, the tracer was connected to an antenna and a station 80 miles away received.

The revised signal tracer worked very well. Signals could be traced from antenna to voice coil, a.v.c., a.f.c., and oscillator circuits could be checked with ease, and by using the phones, noise and distortion could be isolated to the defective stage. Total cost of the modification—less than $10.00.

By JACK KING

# REDUCING HUM LEVELS

## *Hum Level of Many Receivers Can Be Notably Reduced*

RECEIVER performance can be improved greatly by reducing hum level. Work of this kind can be profitable if "sold" to the customer, but not everyone will want hum level reduced. Many are not particularly fussy about reception and will be satisfied so long as some sound comes out of the "box." Others may appreciate quality and be willing to pay for it.

Lack of hum in a battery set is very noticeable. With the volume control set at zero, and no signal input, no hum can be heard. In an a.c. or a.c.-d.c. set, a definite hum can be heard at zero volume control setting or when the radio program is interrupted, as at station-break time. This hum level—sometimes called "residual" hum—is a part of the radio design. It is usually not reduced to absolute zero but is made low enough that ordinarily it is not noticeable.

The hum heard in the service shop *may be less noticeable* than in the home or place where the radio is used. The reason primarily is that noise level in the shop may be high, preventing the serviceman from hearing the hum very efficiently. Baffling effect of a cabinet is also absent on the bench, often causing strong 60-cycle hum to be inaudible. By turning off other sets and keeping shop noise down to a low level when checking hum, better accuracy in making the listening test is possible.

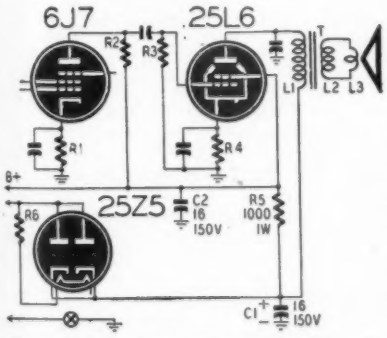



Fig. 1—Hum voltage sources in a.c.-d.c. sets.

Many of the less expensive sets have little filtering, since filter parts cost money and that increases the cost of manufacturing the radio. It might be impractical to use extensive hum reduction on many thousands of radios in manufacturing, but in specialized servicing, for superior results, it is a practical matter to see about reducing the hum to a very low level.

One common type of circuit is that shown in Fig. 1. In this circuit, a hum voltage exists across $C_1$, the input filter condenser. This hum voltage is applied to the series circuit consisting of $L_1$, the plate-to-cathode resistance of the output tube and to $R_4$. The value of $R_4$ may be about 150 ohms and, since it is shunted by a high capacity condenser, the impedance in the cathode circuit may be assumed to be very low at the fundamental and low-order harmonic hum frequencies. Small dimensions of the midget cabinet and poor loudspeaker response at 60 cycles may mean that the hum at second harmonic 120 cycles, will be most noticeable, and hum at 180 and 240 may be appreciable. Rectified alternating current from the cathode of the 25Z5 consists of two components, the d.c. and an imposed a.c., or hum voltage. Such voltage appearing in the plate circuit of the 25L6 would be heard in the speaker. We may think of this 60-cycle hum component as having two paths—one to ground through $C_1$, and the other through $L_1$, the internal resistance of the tube and the cathode resistor and its by-pass condenser. Even at 60 cycles, the reactance of the condenser is only 166 ohms, whereas that of the parallel circuit amounts to some thousands of ohms. As the hum frequency is made higher, the reactance of $C_1$ decreases and that of $L_1$ increases, further reducing the tendency for hum to flow in the plate circuit.

In the screen grid circuit, filtering is obtained through $R_5$ and condensers $C_1$ and $C_2$ which offer low impedance paths for hum currents.

A reduction in hum can be obtained by using a small iron core inductance in series with $R_5$. If the choke d.c. resistance is 200 ohms, $R_5$ may be reduced to 800 ohms. Usually, $R_5$ can be dispensed with entirely when the choke is substituted without noticing any bad effects. If the choke is a 10-henry type, its reactance at 60 cycles is 3768 ohms. The d.c. voltage drop in the choke will be low, but the impedance to hum will be much higher than that offered by the 1000-ohm resistor, reducing the hum level. At 120 cycles, the impedance would be even higher, about 7536 ohms. If a 30-henry choke is used, at 60 cycles, the impedance would be 11,304 ohms, while at 120 cycles it would be 22,608 ohms. (Using the choke in series with the entire B supply may be undesirable since the high plate current of the output tube results in near-saturation of the choke and decreased inductance.)

An ordinary carbon resistor, such as $R_5$, will have no appreciable reactance and may be considered a pure resistance, so that its opposition to hum harmonics is the same as that to the fundamental hum frequency.

Hum can also be reduced, of course, by increasing the values of $C_1$ and $C_2$. Usually $C_2$ is not very critical and a 30-μf 150-volt unit can be used, but $C_1$ must not be made too large in value. Using a very large condenser here will raise the peak current through the rectifier tube and possibly shorten its life. It may also give too much output voltage. Using a choke, the original operating voltages are not disturbed very much. In many cases, however, installing a 20- or even 30-μf unit in place of $C_1$ will work out all right. A 40-μf or higher condenser should not be used in place of $C_1$. If the original circuit had a very high capacity input, the use of a similar condenser in servicing, naturally, would be all right.

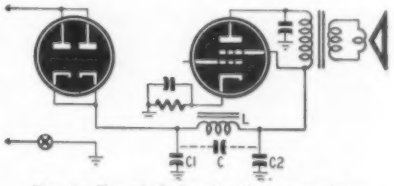



Fig. 2—Tuned-choke circuit, a rarer type.

In Fig. 2, a less widely-used type of circuit is shown. Hum output from the rectifier is a 60-cycle hum, since a half-wave rectifier is used. It may be possible to tune L. L may be a speaker field or a choke. If the inductance is 30 henrys, the reactance at 60 cycles will be about 11,304 ohms. When the reactance is known, the condenser capacitance can be found using a formula, $X_c = 1/6.28xC$ (farads), a condenser in the neighborhood of 0.25 will be found to have the same reactance.

Using an a.c. voltmeter, and connecting it across the output filter $C_2$, the reduction in hum output can be noted as various values of C are shunted across L. Tuned-filter reduction is primarily at the fundamental hum frequency. Above resonance, for example at 120 cycles, the second harmonic hum output of the half-wave rectifier, the 0.25 μf condenser would have a reactance of 5300 ohms. The reactance of the .25 μf condenser, would be in shunt with the choke impedance and the net impedance would be something less than 5300 ohms. For higher harmonic frequencies, the impedance would progressively become less, since the reactance of the condenser drops off with a rise in frequency.

*(Continued on page 648)*

# "RADIO PEN" 28 YEARS OLD

### Dr Lee de Forest Original Inventor

AFTER having published Fips's lurid account of his Radio Pen, which caused him to be immediately fired, cashiered, dismissed, and forbidden to ever re-enter the premises, for his dastardly conduct in stealing inventions of others (see article RADIO PEN, April issue), RADIO-CRAFT received a letter from Dr. Lee De Forest, who writes in part as follows:

"Mr. Hugo Gernsback
"Editor, RADIO-CRAFT

"I notice that your April issue illustrates and partly describes the 'Radio Pen.' I remember distinctly that I made complete drawings and specifications of such a pen away back, either in the early 20's or possibly as far back as 1917. My recollection is that one of your magazines made quite a feature of this. At that time, the smallest available radio tube was the 'peanut,' made by Western Electric.

"If you are sufficiently interested, I suggest that you have one of your men dig back through those early files to see if that published description can be located. If so, will you not please reproduce it? You see, I am just as jealous as you are to be known as an early prophet!"

Sincerely yours,
LEE DE FOREST

Dr. De Forest's memory is very good. We located the article in the June 1918 ELECTRICAL EXPERIMENTER, an early Gernsback publication.

We reprint here a condensation of the article, and also the illustrations that went with it. It certainly makes interesting reading.

In defense of Fips; we are certain that he did not remember Dr. De Forest's original account, because no reference to it was made anywhere in his papers, through which we looked carefully after his brusque dismissal.

We did, however, find the following: He had made numerous notes on other miniature radio receivers, to wit:

POCKET LIGHTER RADIO
TIE-STICK PIN RADIO
EARRING RADIO (For ladies)
COLLAR-BUTTON RADIO
CUFF-LINK RADIO

This should give a good idea how his mind works.

Of course, it will probably turn out that neither of the suggestions mentioned are original with him. We are certain that somewhere, some patentee or an early inventor will sooner or later claim credit.

All this is as it should be. Most so-called "inventors" these days find that after they are through with their laborious work they discover that their brainchild is as old as the hills, and that somebody had preceded them possibly before they were even born.

Dr. De Forest's article from the June 1918 issue ELECTRICAL EXPERIMENTER follows:

#### A "FOUNTAIN PEN" RADIO RECEIVING SET

To Dr. Lee De Forest must be given the credit for developing a receiver which is only slightly larger than an ordinary fountain pen. With it, a secret service man has but to walk in the vicinity where a "spy radio station" is suspected, with the chance that he may locate the informer at his instrument.

With this "fountain pen" radio receiver it has been possible to hear stations eight to ten miles away, with little difficulty and only a small aerial. In the sectional view shown here it may be seen how it is hooked up. This sensitive receiver depends entirely upon the Audion for its efficiency, and it is only this extremely sensitive detector that has made possible a truly practical receiver of this small type.

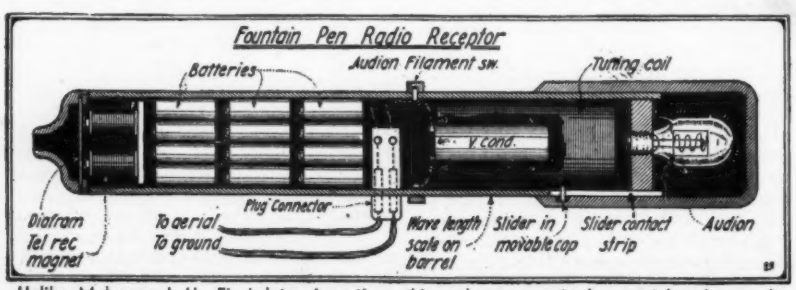
It has been found that by using what is known as a "soft" Audion a fair degree of sensitiveness is achieved with a battery of only four volts, whereas a standard Audion requires a potential many times that amount.

The tuning of the set is accomplished by means of a small coil, wound with No. 40 magnet wire. Taps are taken off from the coil and led to a number of points over which slides a contact mounted on the movable cap at the end of the receiver. By moving the cap one way or another the wave-length is altered to conform with the in-coming wave. The tuning coil answers satisfactorily for short wave-lengths, and the Audion is connected directly to it, having an untuned secondary. The battery is placed in the middle of the receiver and at the end is placed the telephone receiver consisting of a special magnet, bobbin, diaphragm and earpiece. The antenna and ground connections are instantly made by a special double contact plug.

The older (and much bigger) Radio Pen had a range of 10 miles.

To operate the instrument the person using it has a metal plate attached to the heel of one shoe, to which is attached the ground wire leading to the set, the wire being passed through the trouser leg so as not to be seen. The wire to the antenna is run down through the coat sleeve and into a hollow cane which may contain a spiral aerial or a similar arrangement.

Standing against an iron fixture which connects with the ground the operator places the metal electrode on the heel in contact with the same. The cane containing the antenna is held over the shoulder or in any position not likely to cause attraction. The earpiece is placed against the ear and the other end adjusted till the signals are heard loudest.




Unlike Mohammed U. Fips' later invention, this early pen required an aerial and ground.

## CORRECTION

The coil table mentioned in the article "A Portable Shop," published in the February issue, was inadvertently omitted. As a large number of readers have written to ask about the table, it is reproduced below.

No doubt many readers have already constructed the apparatus, using coils of their own design. If they have arrived at values which cover the spectrum and oscillate satisfactorily, it will not be worth while to modify them to conform with the table. Any set of coils that cover the bands is correct. In many cases the cathode tap will have to be varied from the point given, to accommodate individual differences.

**Coil Table**
(all coils are wound on 1½ in. forms)

I.F. coil (456 kilocycle) No. 26 enamel wire. 170 turns close wound; cathode tap 50 turns from ground.
Broadcast—No. 22 d.c.c 100 turns close wound; cathode tap 13 turns from ground.
80 Meter—No. 22 d.c.c. 29 turns close wound; tap 2 turns from ground.
40 Meter—No. 22 d.c.c. 16 turns spaced 1¾ inch; tap 1½ turn from ground.
20 Meter—No. 22 d.c.c. 7 turns spaced 1¼ inch; tap 1½ turn from ground.

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# WORLD-WIDE STATION LIST

AT last the effect of sun spots and the northern lights have diminished and some fair reception has been enjoyed by our observers. We sure hope that it will last a while so that some of the dx can be written into the log. The best European reception seems to be coming from the Swiss transmitters at Berne. 6.345 megacycles is very good at 8:30 pm on and 7.380 is fair at the same time. Some code interference is heard on the latter, however.

A new Mexican has been reported on 11.80 megacycles at 1 to 11 pm. The call is XERH. Brazzaville is now heard on 9.980 megacycles at 5 to 8 pm; with the news at 5:15 and 6:30 pm. On 9.745 megacycles, Leopoldville is again being heard at 1 to 9:30 pm daily. These same programs can also be heard on 9.350 megacycles, at the same hours. This is a new frequency for this transmitter.

VUD3 from Delhi, India, is now being heard on the east coast occasionally at 8:30 to 11:30 am. Reception is fair from this one. VE9AI has discontinued use of the 6.005 megacycle frequency. The German transmitter at Leipzig is being heard from 3 to 7:45 pm and from midnight on. It is a very good signal, and easily received. Identification is by the piano notes of the old folk song used by Berlin transmitters before and during the war. It is the best German heard in a long time. Programs are in the Home Service and is in all German language.

KU5Q on Guam is still good around 7 am on 9.670 megacycles. ZQI in Jamaica is heard from 4:30 to 6:30 pm on 4.700 megacycles.

Reception reports on HIT should be sent to Calle Arzobispo Nouel 24 altos, Ciudad Trujillo, Dominican Republic. Reports should be in Spanish, and *be sure to inclose international reply coupon.* The programs are heard nightly on 6.630 megacycles until sign-off at 9 pm. The station identification is made by a man who says, "El HIT Del Airo," and sign-off is followed by the National Anthem.

XEBT in Mexico City is also sending verification cards in return for good, complete reports, which should be in Spanish. They are heard very well about 8 pm on 9.625 megacycles.

*All schedules Eastern Standard Time.*

| Freq. | Station | Location and Schedule |
|---|---|---|
| 11.800 | JZJ | TOKYO, JAPAN; 9 to 10 am. |
| 11.810 | WLWLI | CINCINNATI, OHIO; European beam, 6 to 7:45 am; 1 to 5:45 pm. |
| 11.810 | ZOJ | COLOMBO, CEYLON; 5 am to noon. |
| 11.820 | GSN | LONDON, ENGLAND; New Zealand beam, 12 to 1 am; African beam, 1 to 4 pm. |
| 11.828 | WCRC | NEW YORK CITY; European beam, 6 to 10:30 am. |
| 11.830 | WCRC | NEW YORK CITY; European beam, 10:45 am to 4:30 pm; South American beam, 5 to 11 pm. |
| 11.830 | | MOSCOW, U.S.S.R.; 10 pm to 2 am; 6 to 8 am; 11 to 11:30 am; 6 to 7 pm. |
| 11.835 | CXAI9 | MONTEVIDEO, URUGUAY; 6 am to |
| 11.840 | GWQ | 10 pm. |
| | | LONDON, ENGLAND. |
| 11.840 | VLG4 | MELBOURNE, AUSTRALIA; North American beam, 12:10 to 12:45 am; 10 to 10:45 am; New Caledonia beam, 3:10 to 4 am; Southwest Pacific beam, 4:30 to 5:15 am; Asiatic beam, 5:15 to 6:45 am. |
| 11.840 | VLC7 | SHEPPARTON, AUSTRALIA; Tahiti beam, 1 to 1:40 am. |
| 11.845 | | PARIS, FRANCE; 8 to 9:45 pm; 10 to 10:45 pm; 11 to 11:45 pm; midnight to 3 am; noon to 5 pm; 5:30 to 7:30 pm. |
| 11.847 | WGEA | SCHENECTADY, NEW YORK; European beam, 6 am to 3:45 pm; Brazilian beam, 4 to 10:30 pm. |
| 11.847 | XMHA | SHANGHAI, CHINA; 6 to 9 am. |
| 11.855 | | SINGAPORE, MALAYA; 8 to 9:30 am. |
| 11.860 | GSE | LONDON, ENGLAND; Near and Middle East beam, 11:45 pm to 5 am; 1:30 to 2 pm; African beam, 3:30 to 4 pm; European beam, 11:30 to 1:45 am; 5 to 8 am; 10:15 am to 11:30 am; 12 to 4 pm. |
| 11.860 | | RANGOON, BURMA; 10 pm to 1 am; 2:15 to 3 am; 8:30 to 10 am. |
| 11.870 | WNBI | NEW YORK CITY; South American beam, 6:30 to 11 pm. |
| 11.870 | WOOW | NEW YORK CITY; European beam, 6 am to 5:45 pm. |
| 11.880 | LRR | ROSARIO, ARGENTINA; heard at 7:30 pm. |
| 11.885 | | MOSCOW, U.S.S.R.; 6:45 to 8 am; 6:30 to 7:30 pm. |
| 11.890 | KWIX | SAN FRANCISCO, CALIF.; Hawaiian beam, 4 pm to midnight; 12:15 to 1:45 am. |
| 11.893 | WNBI | NEW YORK CITY; European beam, 1:15 to 4:45 pm. |
| 11.897 | JVU3 | TOKYO, JAPAN; 6:45 am to 12:30 pm. |
| 11.900 | XGOY | CHUNGKING, CHINA; Allied forces in the Far East, 7 to 8 pm; Asia, Australia, New Zealand beam, 5 to 5:30 am; East Russia beam, 5:30 to 6 am; Japan beam, 6 to 6:30 am. |
| 11.900 | CXA10 | MONTEVIDEO, URUGUAY; 3:30 to 9 pm. |
| 11.930 | GVX | LONDON, ENGLAND; North American beam, 5 to 7 am; 2:30 to 4 pm; 4:15 to 9 pm; Indian beam, 10:30 am to 12:15 pm. |
| 11.950 | | MEXICO CITY, MEXICO; heard evenings. |
| 11.955 | GVY | LONDON, ENGLAND; European beam, 5 to 7:30 am; Near East beam, 1 to 4 pm. |
| 11.960 | HEK4 | BERNE, SWITZERLAND; Tuesday and Saturday, midnight to 1:30 am. |
| 11.970 | FZI | BRAZZAVILLE, FRENCH EQUATORIAL AFRICA; 11 am to 6:45 pm; midnight to 2:30 am. |
| 11.955 | CSX | LISBON, PORTUGAL; 8 to 10 am. |
| 12.000 | CE1180 | SANTIAGO, CHILE; late afternoons. |
| 12.040 | GRV | LONDON, ENGLAND; Australian beam, 12 to 4 am. |
| 12.070 | CSW | LISBON, PORTUGAL; heard 1:30 to 3 pm. |
| 12.080 | PST | RIO DE JANEIRO, BRAZIL; 6 to 7 pm. |
| 12.080 | | MOSCOW, U.S.S.R.; 8 to 11 am. |
| 12.095 | GRF | LONDON, ENGLAND; Near East beam, 1 to 3:15 am; 11 am to 12:45 pm; Italian beam, 1 am to 12:45 pm. |
| 12.110 | HI3X | CIUDAD TRUJILLO, DOMINICAN REPUBLIC; noon to 2:30 pm; 6 to 10:30 pm. |
| 12.175 | | MOSCOW, U.S.S.R.; 6:45 to 7:45 am; 8:30 to 10:30 am; noon to 1 pm; 7 pm to 1 am. |
| 12.190 | LSN3 | BUENOS AIRES, ARGENTINA; 6.15 pm. |
| 12.210 | | VIENNA, AUSTRIA; afternoons at 4:30 pm. |
| 12.250 | WXFD | ALASKA; 8 pm to midnight. |
| 12.255 | KU5Q | GUAM; 5 am; 7 pm to midnight. |
| 12.265 | | MOSCOW, U.S.S.R.; 4 to 5:30 pm; 8 to 9:30 pm; 10 pm to 6 am; 7 am to 1 pm. |
| 12.265 | TFJ | REYKJAVIK, ICELAND; 8 to 9 am; 3 to 6:30 pm. |
| 12.270 | | HAVANA, CUBA; evenings. |
| 12.445 | HCJB | QUITO, ECUADOR; afternoons and evenings. |
| 13.000 | HDD | QUITO, ECUADOR; 2:45 to 3:30 am. |
| 13.050 | WNRI | NEW YORK CITY; European beam, 6 am to 6 pm. |
| 13.050 | KCBR | SAN FRANCISCO, CALIF; Oriental beam, 10:15 pm to 1 am. |
| 14.560 | WNRX | NEW YORK CITY; European beam, 6 am to 3:45 pm. |
| 15.000 | WWV | WASHINGTON, D. C.; U. S. Bureau of Standards; frequency, time and musical pitch; broadcasts continuously day and night. |
| 15.070 | GWC | LONDON, ENGLAND; Far East beam, 5 to 10:15 am. |
| 15.105 | | TOKYO, JAPAN; heard at 7:30 pm. |
| 15.110 | GWG | LONDON, ENGLAND; Near and Middle East beam, 6:15 to 6:45 am; 1:30 to 2 pm; African beam, 12:30 to 12:45 pm; European beam, 5 to 8 am; 10:15 am to 2 pm; 2:30 to 4 pm. |
| 15.110 | HCJB | QUITO, ECUADOR; mornings and afternoons. |
| 15.130 | KGEI | SAN FRANCISCO, CALIF.; Alaska-Oriental beam, 5 to 7:45 pm; Southwest Pacific beam, 8 pm to midnight. |
| 15.130 | WRUW | BOSTON, MASS.; European beam, 6 to 8:45 am. |
| 15.140 | GSF | LONDON, ENGLAND; Australia beam, 1:30 to 4 am; Indian beam, 11 pm to 12:45 am. |
| 15.120 | HVJ | VATICAN CITY; Wednesdays, midnight to 12:20 am. |
| 15.150 | WRCA | NEW YORK CITY; European beam, 7:30 am to 3:30 pm; Brazilian beam, 4 to 6:45 pm. |
| 15.150 | KNBX | SAN FRANCISCO, CALIF.; Oriental beam, 9 to 11:45 pm. |
| 15.155 | SBT | STOCKHOLM, SWEDEN; 6 to 7 am; 10 am to 1:15 pm; Sundays, 2:45 am to 1:15 pm. |
| 15.160 | JZK | TOKYO, JAPAN; heard at 7:30 pm. |
| 15.170 | TGWA | GUATEMALA CITY, GUATEMALA; daytime transmissions. |
| 15.180 | GSO | LONDON, ENGLAND; Near East beam, 12:15 am to 3:30 pm. |
| 15.190 | CKCX | MONTREAL, CANADA; European beam, 7 am to 3 pm. |
| 15.195 | TAQ | ANKARA, TURKEY; 4:15 to 8 am. |
| 15.200 | WLWSI | CINCINNATI, OHIO; South American beam, 5 to 7:15 pm. |
| 15.200 | VLA6 | MELBOURNE, AUSTRALIA; Japanese beam, 2:30 to 3:30 am. |
| 15.200 | WOOC | NEW YORK CITY; European beam, 6 am to 3:15 pm. |
| 15.210 | KGEX | SAN FRANCISCO, CALIF.; Philippine beam, 4 pm to 1:45 am. |
| 15.210 | WBOS | BOSTON, MASS.; European beam, 6 am to 12:45 pm. |
| 15.220 | CHTA | MONTREAL, CANADA. |
| 15.225 | JTL3 | TOKYO, JAPAN; 5:15 to 7:15 pm. |
| 15.230 | VLG6 | MELBOURNE, AUSTRALIA; Northern Australia beam, 10 to 10:25 pm. |
| 15.230 | WLWL2 | CINCINNATI, OHIO; North African beam, 6 to 7:45 am; 8 am to 12:45 pm; 1 to 5:45 pm. |
| 15.230 | | MOSCOW, U.S.S.R.; 5:45 to 6:25 pm; 6:45 to 8:15 am; 3 to 3:45 pm. |
| 15.240 | KNBX | SAN FRANCISCO, CALIF.; Oriental beam, 3:45 to 8:45 pm. |
| 15.250 | WLWK | CINCINNATI, OHIO; South American beam, 5 to 7:15 pm. |
| 15.250 | WLWRI | CINCINNATI OHIO; North African beam, 7:30 am to 3 pm. |
| 15.260 | GSI | LONDON, ENGLAND; African beam, 10:30 am to 2:15 pm. |
| 15.270 | WCBX | NEW YORK CITY; European beam, 6 am to 3:45 pm. |
| 15.270 | KCBR | LOS ANGELES, CALIF.; Oriental beam, 4 to 10 pm; 10:15 pm to 1 am. |
| 15.280 | WNRE | NEW YORK CITY; European beam, 7:30 am to 4:15 pm. |
| 15.290 | WRUL | BOSTON, MASS.; North African beam, 9 am to 5 pm; Caribbean beam, 5:15 to 5:45 pm. |
| 15.275 | ZOJ | COLOMBO, CEYLON; news at 10 pm and midnight. |
| 15.290 | VUD3 | DELHI, INDIA; 7 to 8 am. |
| 15.300 | GWR | LONDON, ENGLAND; South American beam, 2:30 to 4:45 pm; Central American beam, 5 to 6:15 am; 2:30 to 4:45 pm. |
| 15.310 | GSP | LONDON, ENGLAND; North American beam, 6:15 am to 6 pm; African beam, 1 to 3 am; Near and Middle East beam, 5:15 to 5:30 am. |
| 15.315 | HER6 | BERNE, SWITZERLAND; Mondays, 3 to 3:30 am. |
| 15.320 | | MOSCOW, U.S.S.R.; 5 to 11:30 am. |
| 15.325 | JLP2 | TOKYO, JAPAN; 11:45 pm to 4 am. |
| 15.330 | WGEO | SCHENECTADY, NEW YORK; European beam, 6 am to 4:30 pm. |
| 15.340 | KNBI | SAN FRANCISCO, CALIF.; South American beam, 5 to 11:45 pm; Oriental beam, 2 to 4:45 pm. |
| 15.340 | | MOSCOW, U.S.S.R.; 5:30 to 9:30 am. |
| 15.350 | WRUA | BOSTON, MASS.; European beam, 6 am to 4:15 pm. |
| 15.350 | | PARIS, FRANCE; 6 to 8 am. |
| 15.375 | GRE | LONDON, ENGLAND. |
| 15.405 | PZX5 | PARAMARIBO, SURINAM; 12:30 to 1 pm. |
| 15.420 | GWD | LONDON, ENGLAND; Australian beam, 1:30 to 4 am; New Zealand beam, 1:30 to 4 am. |
| 15.435 | GWE | LONDON, ENGLAND; Middle East beam, 12 to 2:15 pm; South American beam, 2:30 to 4:45 pm. |
| 15.450 | GRD | LONDON, ENGLAND; African beam, 10:30 am to 2:15 pm. |
| 15.505 | CMA5 | HAVANA, CUBA; 6:45 to 7:30 pm. |
| 15.595 | FZI | BRAZZAVILLE, FRENCH EQUATORIAL AFRICA; 4:45 to 8 am. |
| 15.620 | VRR6 | JAMAICA, BRITISH WEST INDIES. |
| 15.810 | LSL3 | BUENOS AIRES, ARGENTINA; heard mornings. |
| 15.875 | HEO4 | BERNE, SWITZERLAND; 2:15 to 2:50 pm. |
| 15.920 | KU5Q | GUAM; 7 pm to midnight. |
| 17.445 | HVJ | VATICAN CITY; Wednesdays and Saturdays, 8:45 to 9:15 am. |
| 17.527 | FZI | BRAZZAVILLE, FRENCH EQUATORIAL AFRICA; midnight to 2:30 am; 4:45 to 7:45 am; 11 am to 5 pm. |

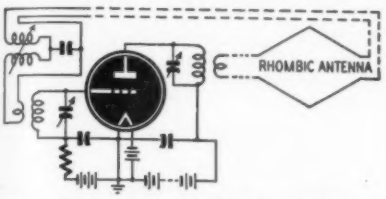
*(Continued on page 660)*

## NEW RADIO ELECTRONIC PATENTS

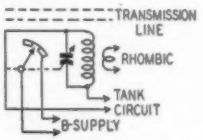
### ANTENNA SYSTEM

George T. Royden, S. Orange, N. J.
Patent No. 2,393,656

A RHOMBIC ANTENNA is known as an excellent wide-band system. However, it requires a resistance termination for optimum results. This resistor must dissipate sufficient energy to prevent reflection along the antenna.




Instead of a resistor, this rhombic uses a transformer as a termination, for the purpose of transmitting some of the antenna energy back into the transmitter input. Therefore two effects are accomplished; antenna reflections are eliminated; oscillations are maintained. The transmission line between antenna output and transmitter input can be made of suitable length so that phase relations are satisfied for oscillations at the required frequency.

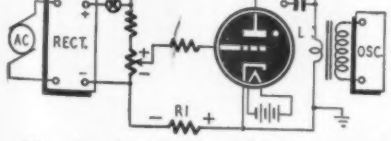



The inventor suggests the use of this system in connection with radar or radio jamming facilities. For these purposes the tuning condenser is rotated continuously through the desired band of frequencies. On the same shaft is connected a rotary arm contacting a metal band. This constitutes the B-minus return. At one position an interruption on the metal band is provided, so that during this moment (corresponding to the desired frequency) no jamming takes place. This frequency, which may be set at any desired point in the band covered by the apparatus, is used for communication transmission.

### PULSE MODULATOR

John E. Gorham, Spring Lake and
Andrew W. Frevert, S. Belmar, N. J.
Patent No. 2,391,894

THIS circuit is designed to shape as well as time the pulses used to modulate an r.f. amplifier. An alternating current is rectified and applied to a thyratron control circuit. This voltage charges the condenser at a rate determined by the resistance and capacitance in the circuit. The charging current flowing through R1 puts a negative voltage on the grid which opposes the existing positive voltage, and as it dies down, two effects tend to break down the tube: (a) the rising plate voltage (b) the rising grid voltage. The variable resistor is adjusted to fire the tube at the moment of peak condenser voltage.




When the tube fires it permits the condenser to discharge through it (L prevents sudden current flow), the resulting oscillatory flow reversing the condenser voltage and quickly extinguishing the tube.

With the rectified voltage shown, the pulse rate will be twice that of the applied a.c. frequency. If pure d.c. is used this rate may be adjusted to any value by changing values of C and L (the transformer primary). The width of the pulse depends upon the size of condenser C.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99 and 999

TURNER MODEL 999 BALANCED LINE DYNAMIC

The same professional appearance and rugged construction as Model 99 with voice coil and transformer leads insulated from ground and microphone case. Line is balanced to the ground. Especially recommended for critical applications. Range 40-9,000 cycles. Level — 52DB. In all standard impedances with removable 20 ft. balanced line, low capacity cable set.

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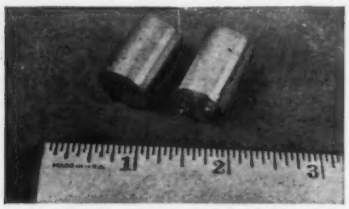
**Cleveland, Ohio**

The Massa Model M 101 Sound Pressure Measurement Standard is a precision acoustic instrument developed for making absolute sound pressure measurements throughout the range.

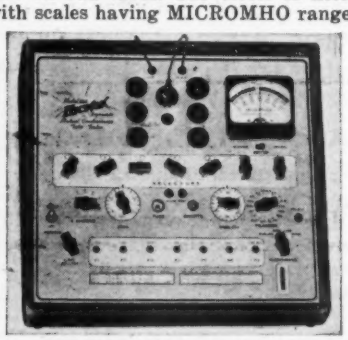


Specifications: Physical Size: ⅝-inch diameter cylinder by 15/16-inch long. Outer Housing: Metallic, chrome plated, electrically independent from both terminal connections. Electrical Connection: Two insulated pins projecting through bottom. Acoustic Impedance: Greater than 0.001 c.c. of air. Resonant Frequency: Above 45 kc, resulting in absolutely uniform pressure sensitivity throughout the audible frequency range. Free Field Response: Non-directional in all planes to 5 kc. Diffraction presented by a rigid cylinder ⅝-inch diameter at higher frequencies. Cavity Resonance: Completely eliminated in the design. Sensitivity: 23 microvolts/dyne/cm² sound pressure. Electrical Impedance: Equivalent to a 100 μμf condenser throughout the entire audible range.—RADIO-CRAFT

## TUBE TESTER

**Hickock Electrical Instrument Co.**
**Cleveland, Ohio.**

The Model 532C (counter model) and 532P (portable) accurately test and reject all bad tubes. The tester is fitted with scales having MICROMHO ranges

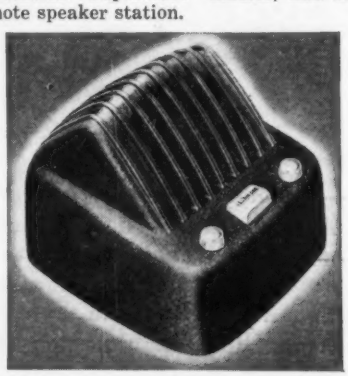


from 0-3000, 0-6000, 0-15,000 with legends indicating "Replace," "Doubtful," and "Good." This unit also provides for noise, gas, and hot and cold shorts tests. Diodes are tested separately with low voltage to prevent paralysis of the elements. Line voltage is indicated correctly on a large test meter—from 100 to 130 volts. Rectified current is used to energize plates and grids, using two rectifiers, and tests can be made of grid controlled rectifier tubes. Filament voltage is in steps to 117 volts. The tester is 17x18x8½-inches in size and operates on a power supply of 110-130 volts from 50-60 cycles. Tube complement is one type 83 and one type 5Y3-GT. Tests of all present-day tubes, including Octal, Loktal, Miniature, Ballast and Magic Eye tubes, can be made and provision has been made for future tube designs.—RADIO-CRAFT

## INTERCOMMUNICATOR

**Operadio Manufacturing Co.**
**St. Charles, Illinois**

The new Flexifone line features a 10-station master, a 20-station master, a 6-station "Supervisor" master, and remote speaker station.



Outstanding features are modern housings of durable die-cast metal; attractive gray-tan Hammerloid finish; self-clearing, gravity-assisted piano-type keyboard for station selector switches; selector keys and controls of plastic.—RADIO-CRAFT

## COMMUNICATIONS RECEIVER

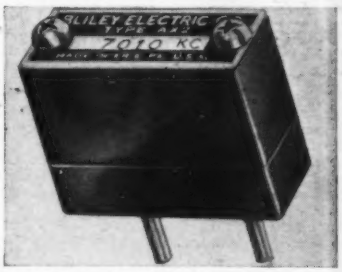
**Hallicrafters Co.**
**Chicago, Illinois**

The S-40 communications receiver features standard broadcast as well as short wave, using red markings for b.c. band. Selection of standard broadcast is thus made so simple that a child can operate it. Frequency ranges from 550 kc to 44 mc are covered in four bands. A nine-tube set, the S-40 is designed primarily for radio amateurs and short-wave listeners, but is also adapted to general use. An external "S" meter which can be connected through a special socket on the rear of the chassis is available as an accessory.—RADIO-CRAFT

## AMATEUR CRYSTAL

**Bliley Electric Co.**
**Erie, Penna.**

This new crystal, Type AX2, features primary electrodes consisting of a micro-thin metal film deposited directly on the major crystal surfaces by evaporation under high vacuum. Secondary



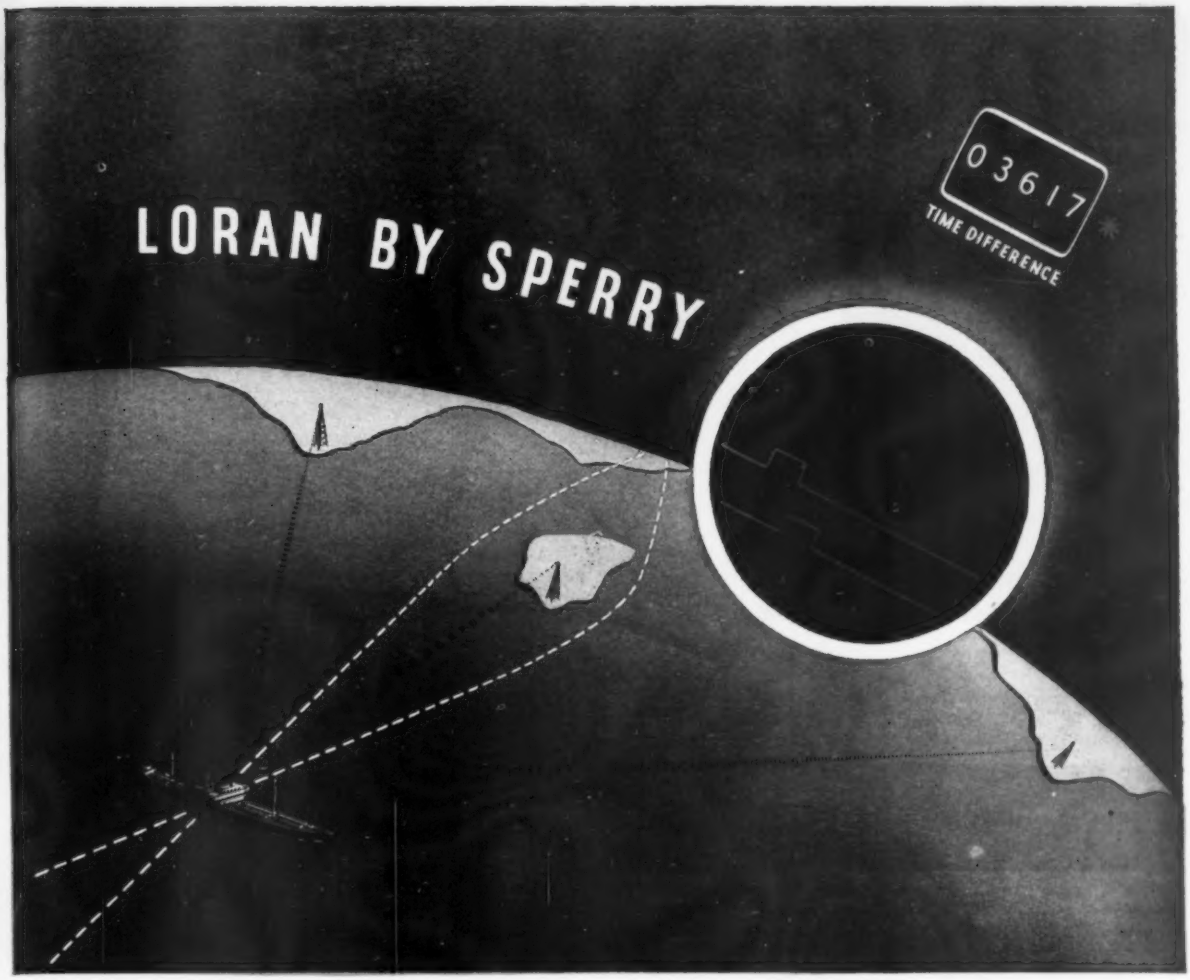

electrodes, under spring pressure, clamp the crystal and provide necessary thermal dissipation. This design results in better grid current stability over a wide temperature range, improved frequency stability under high drive conditions and substantial improvement in keying characteristics.—RADIO-CRAFT

## STUDIO RECORDER

**Fairchild Camera and Instrument Co.**
**Jamaica, N. Y.**

The No. 523 studio recorder is designed to meet the requirements of the commercial recording and radio industry for instantaneous or wax recordings; and the sound film industry for dubbing sound from disk to film. The table accommodates 18-inch flowed wax masters, acetate, or thicker wax masters. The synchronous motor 33.3 r.p.m. drive

guarantees absolute timing, also making the a.c. line the only interlocking device needed for dubbing sound. No. 541 magnetic cutterhead, microscope and mount in combination with the precision-built lead screw mechanism assures uniform cutting at any pitch from 80 to 160 lines.—RADIO-CRAFT




# Accurate LOng RAnge Navigation... anytime... in all weather

With Sperry Loran the navigator has at hand a quick and accurate means of determining a ship's position at any time, in all kinds of weather. This system involves the reception of accurately timed radio pulses from shore-based transmitting stations, usually 200 to 400 miles apart.

The *difference in time of arrival* of signals from a pair of transmitting stations is measured and the time difference is then used to determine, from special charts or tables, a line-of-position on the earth's surface. When two lines-of-position from two different pairs of Loran stations are crossed, you have a *"Loran fix."* Fixes are obtainable at distances from shore stations up to 1400 miles at night, 700 miles in daytime.

In your consideration of Loran, note particularly that Sperry's equipment is easy to operate. A Time Difference Meter (see illustration above) greatly simplifies the operator's work and prevents errors in readings.

Sperry Loran is backed by a world-wide service organization and meets the usual high standards of test and performance of all Sperry products. *Loran equipments in limited quantity are ready for immediate delivery.*

**The Time Difference Meter, giving position references* directly, *is a Sperry exclusive.*

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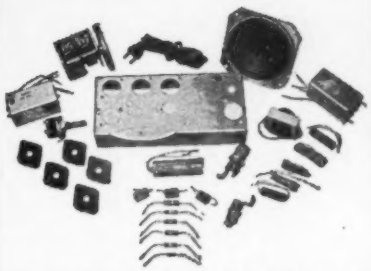

These Special Kits include: Stamped Chassis-Dynamic Speakers, Output Transformer, Volume Control and Switch, 2 Shielded I.F. Coils, Antenna and Osc. Coils, Two-gang Super Variable, 5 Octal Sockets, 20 x 20 Mfd. 150-Volt Filter, 5 Tubular Condensers, 3 Mica Condensers, 6 Resistors, 6 ft. A.C. Cord and Plug, Circuit Diagram.

WHILE THEY LAST **$8.95** each

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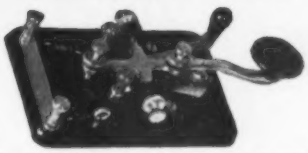
## SIGNAL CORPS TELEGRAPH KEYS



Genuine U.S. Signal Corps telegraph keys brought to you at prices below manufacturing costs. Made with switch to close contacts, polished durable enameled metal base mounted on a bakelite base; key lever is nickel-plated; contacts are brass-silver.

Packed in new original boxes.

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Carton of 50 **60¢** ea.

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Western Electric—0-200 Microamps D.C. — Zero adjustment, — Bakelite Case — 3-inch meter — Individually boxed.

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This Record Changer is a well-made mechanism, will play either 10-in. or 12-in. records. The pick-up uses a crystal cartridge. Size 14 in. x 14 in. Packed 2 to a factory-sealed carton, factory guaranteed.

Special $20.95 each

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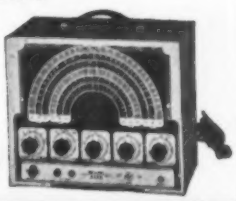
## Approved SIGNAL GENERATOR Model A-100

A—100 to 310 Kilocycles
B—320 to 1000 Kilocycles
C—1000 to 3200 Kilocycles
D—3.2 to 10.5 Megacycles
E—10.5 to 25 Megacycles
E2—21 to 52 Megacycles

440 Standard Audio Frequency (same as WWV). Internal modulation at 440 cycles (same as WWV). External modulation possible from 40 to 30,000 cycles. Complete



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50 mfd. 150 Vo. ..... $33.00 per 100
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Standard Brands, Tubular By Pass Condensers .001—.002—.003—.005—.006—600 Volt ..... $6.75 per 100
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456 K.C. I.F. Coils Input & Output, medium size can .....$45.00 per 100 asst.
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Volume Controls, less Switch—1½" shaft, 250,000 ohm. 1 Meg Lots of 100 2 Meg $27.50

Kit of 50 assorted Bakelite Knobs for ¼ in. shaft, with set screws .....$2.50 per kit

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Mazda Pilot Bulbs No. 44 Packed 10 to box $4.25 per 100 1000 to Carton $38.50 per 1000
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Finest Quality Midget Micas:
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Filter Choke, 75 Mill.—250 ohms-¾ in. Core, 85c ea.
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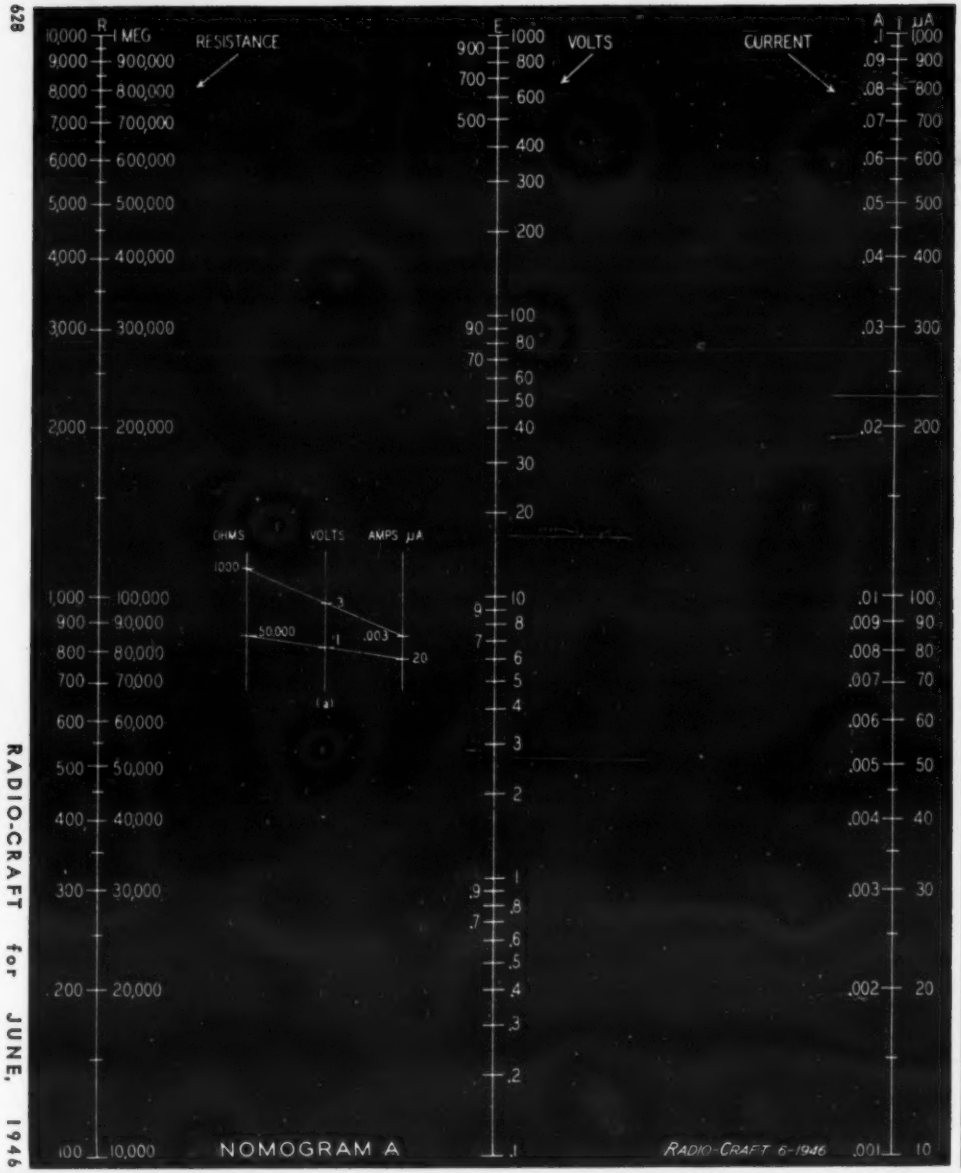
## CALIFORNIA RADIO & ELECTRONICS CO.

DEPT. NO. C 711 NO. VERMONT AVE., LOS ANGELES 27, CALIFORNIA

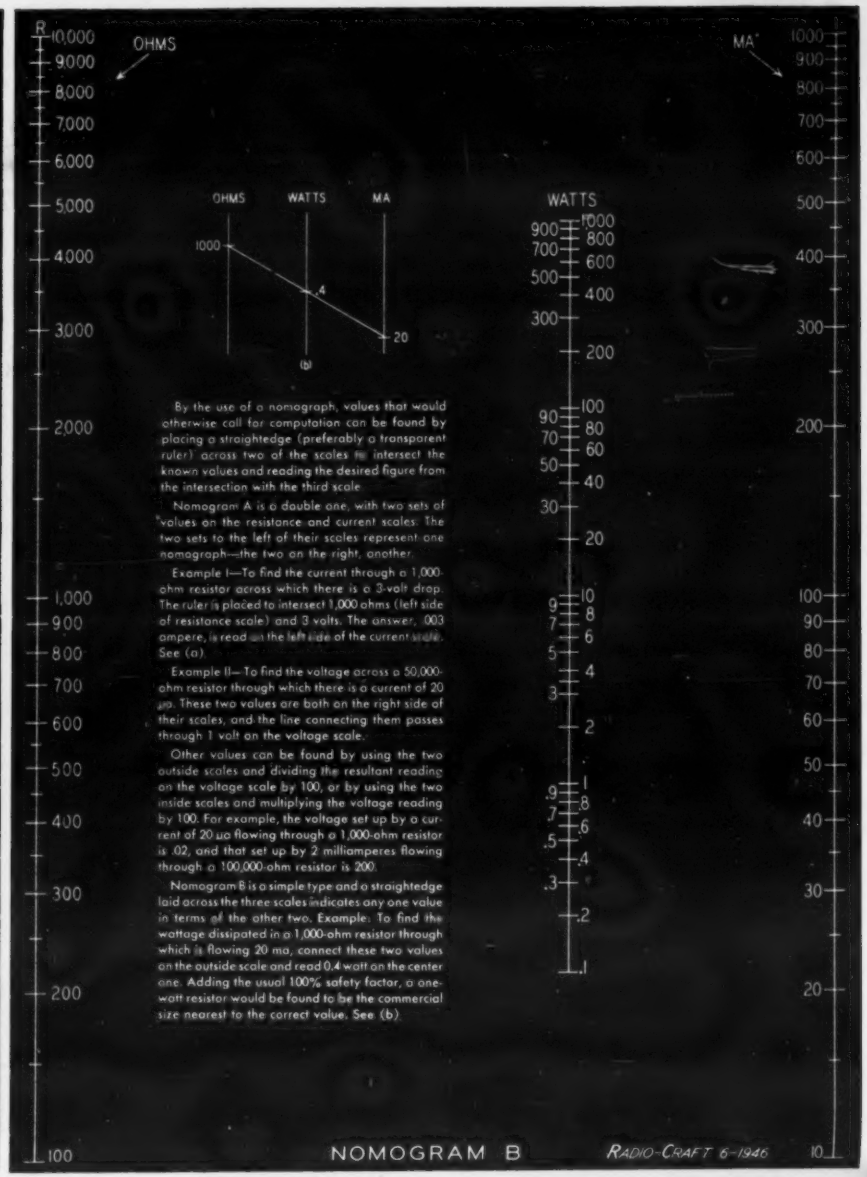
# OHM'S LAW IN GRAPH FORM




NOMOGRAM A

RADIO-CRAFT 6-1946

# WATTAGE FROM OHMS AND AMPS




By the use of a nomograph, values that would otherwise call for computation can be found by placing a straightedge (preferably a transparent ruler) across two of the scales to intersect the known values and reading the desired figure from the intersection with the third scale.

Nomogram A is a double one, with two sets of values on the resistance and current scales. The two sets to the left of their scales represent one nomograph—the two on the right, another.

Example I—To find the current through a 1,000-ohm resistor across which there is a 3-volt drop. The ruler is placed to intersect 1,000 ohms (left side of resistance scale) and 3 volts. The answer, .003 ampere, is read on the left side of the current scale. See (a).

Example II—To find the voltage across a 50,000-ohm resistor through which there is a current of 20 μa. These two values are both on the right side of their scales, and the line connecting them passes through 1 volt on the voltage scale.

Other values can be found by using the two outside scales and dividing the resultant reading on the voltage scale by 100, or by using the two inside scales and multiplying the voltage reading by 100. For example, the voltage set up by a current of 20 μa flowing through a 1,000-ohm resistor is .02, and that set up by 2 milliamperes flowing through a 100,000-ohm resistor is 200.

Nomogram B is a simple type and a straightedge laid across the three scales indicates any one value in terms of the other two. Example: To find the wattage dissipated in a 1,000-ohm resistor through which is flowing 20 ma, connect these two values on the outside scale and read 0.4 watt on the center one. Adding the usual 100% safety factor, a one-watt resistor would be found to be the commercial size nearest to the correct value. See (b).

NOMOGRAM B

RADIO-CRAFT 6-1946

## NOMOGRAPH CONSTRUCTION

*(Continued from page 609)*

In Nomogram A, (shown on opposite page), one of the ranges (figures to the right of the scale lines) is 10 microamperes to one milliampere (1/100,000 to 1/1,000 ampere) and 10,000 ohms to 1 megohm. The other range (figures to the left of the scale lines) is from 1 milliampere to 0.1 ampere and from 100 to 10,000 ohms.

Since our outside scales range from 1 to 100, the center voltage scale might be expected to start with 1 (1 × 1) and end with 10,000 (100 × 100). But the two outside scales in this nomogram have been intentionally started with numbers which have a product of 0.1 volt. At the top we have 1 megohm × 1 ma and 10,000 ohms × 0.1 ampere = 1,000 volts in each case. How is the center scale to be constructed? Four-cycle paper is not easily obtained—if at all—in our small size, and the center scale has four cycles.

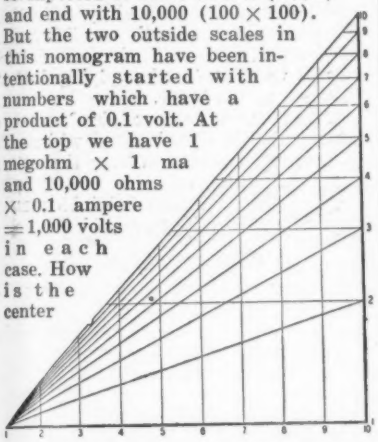


Fig. 3—With this guide (on 10- or 20-inch paper) nomograms may be drawn to any scale.

The device in Fig. 3 solves the problem. This is drawn on 1-cycle paper (or can be drawn on any piece of paper more than 10 inches square with the help of a slide-rule scale). The base is divided into 10 equal parts from 1 to 10 (conveniently 1 inch apart). The altitude is divided logarithmically according to the 1-cycle paper (or the C-scale of a slide-rule). (Much log paper comes seven inches wide and it may be necessary to paste two sheets together, but carefully!) We can make logarithmic scales of any length with this diagonal figure.

To use the diagonal guide on the 4-cycle voltage scale, mark out the 10-volt and 100-volt points on the nomogram. One milliampere × 10,000 ohms = 10 volts. Since these figures appear on both scales, it is necessary only to connect the values together with the usual straightedge, marking the point where it crosses the center line. The two marks should coincide at the 10-volt point. Locate the 100-volt point with 10,000 ohms × .001 ampere and 1,000 ohms × 0.1 ampere, and the 1-volt point with 100,000 ohms × 10 μa and 100 ohms × .01 ampere.

Insert the diagonal guide under the tracing paper, keep its base line directly under the base line of the nomogram,

*(Continued on page 631)*


**Highest Quality**

# RADIO and ELECTRONIC

**Testing Equipment**

**Immediate Delivery from Stock Guaranteed**

**The New Superior Model CA-11 Signal Tracer**

Net Price **$18.75**

FEATURES:
★ Signal intensity readings are indicated directly on the meter.
★ Only one connecting cable—No tuning controls.
★ Highly sensitive—uses an improved vacuum tube voltmeter circuit.
★ Tube and resistor-capacity network are built into the Detector Probe.
★ Completely portable — weighs 5 lbs. Measures 5 x 6 x 7 inches.
★ Provision is made for insertion of phones.

**The New Model 680 5000 Ohms Per Volt VOLT-OHM MILLIAMMETER**

Net Price **$27.65**

D. C. Voltages to—1500 volts. A.C. Voltages to—1500 volts. Resistance to—2 Megohms. Output Volts to—1500 volts. D.C. Current to—150 Ma. Decibels to—+58 D.C.

**The New McMurdo Silver Model 904 Capacitance Resistance Bridge**

Net Price **$49.90**

¼ mmfd/ohm thru 1,000 mfd./megohms; 0-50% power factor; 0-500 volt adjustable internal polarizing voltage; 0-10 and 0-100 ma. electron-ray leakage current meter; measures resistance, capacitance under actual operating voltages!

**The New McMurdo Silver Model "VOMAX" Vacuum Tube Voltmeter**

Net Price **$59.85**

D.C. Volts at 51 and 126 megohms, A.C. and r.f. volts at 6.6 megs. Resistance .2 ohms to 2,000 megs. D.C. current 1.2 ma. through 12 amperes. D.B. —10 through +50. Plus visual dynamic signal tracing.

**The New Model 802N Combination TUBE & SET TESTER**

Net Price **$58.31**

RANGES:
DC Voltmeter: 0/10/50/500/1000 at 1000 ohms per volt
Four Range AC Voltmeter: 0/10/50/500/1000
DC Milliammeter: 0/1/10/1000 DC Ammeter 0/10
DB Meter: −8/15/15 to 29/29/ to 49/32 to 55 decibels
Four Range Output Meter—same as AC Volts

**The New Model 668 Vacuum Tube Volt Ohm Capacity Meter**

Net Price **$73.01**

Ranges:
D.C. Vacuum-Tube Voltmeter: Direct Reading, Sensitivity: 160 to 16 megohms. Six ranges: 0-6 - 30 - 150-600-1500-6000 volts. Voltmeter readings can be taken without affecting circuit constants. A.C. Vacuum-Tube Ohmmeter: Direct reading, input capacity: 0.00005 mfd. at terminals of instrument. Input resistance: 160 to 16 megohms. Seven ranges: 0-3-6-30-150-600-1500-6000 volts. Measures signal and output voltages from 10 cps to 10,000 cps.
Vacuum-Tube Ohmmeter: Direct reading, from 0.1 ohm to 1,000 megohms. Seven ranges: 0-1,000-10,000-100,000 ohms 1-10-100-1,000 megohms. Capacity Meters: Accurate measurements from 0.00005 to 2,000 mfd. Seven ranges: 0-0.002-0.02-0.2-2-20-200-2,000 mfd.

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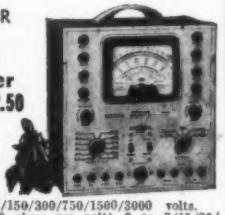

RANGES
DC V.T.M. Volts: 0 to 3/15/30/75/150 / 300 / 750/1500/3000/ volts.
DC Volts: (at 1000 ohms per volt) 0 to 3/15/30/75/150/300/750/1500/3000 volts.
AC Volts: (at 1000 ohms per volt) 0 to 3/15/30/75/150/300/750/1500/3000 volts.
DC Current: 0 to 3/15/30/75/150/300/750 Ma. 0 to 3/15 amps.
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Reactance: 10 to 5M ohms 100-50M ohms .01-5 megs.
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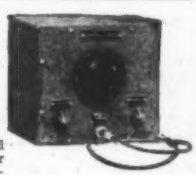

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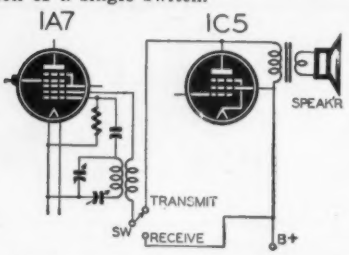
# RADIO·ELECTRONIC CIRCUITS

## HOME BROADCASTER

A radio receiver may be used as a home broadcaster, at will, by the addition of a single switch.




As shown in the circuit, the positive lead to the oscillator tickler coil is broken and the arm of a single-pole double-throw inserted. One of the points of the switch is connected to the plate of the power output tube and the other to the B-plus line. When the switch is in the TRANSMIT position, the oscillator anode (Grid No. 2) may be modulated by speaking directly into the loudspeaker. The broadcaster may be tuned to the desired frequency by using the frequency control dial.

Normal receiver operation is had by throwing the switch to RECEIVE.

GILBERT RUST,
*Evanston, Ind.*

(Note—Obviously, this set will not work if the oscillator is isolated from the antenna by a tuned r.f. stage. For best results, the set should have an antenna that is closely coupled to the oscillator. A loop antenna is probably best. It would also seem that if a d.p.d.t. switch were used and the plate of the output tube cut out in TRANSMIT position, results would be better. As it is now, the two tubes are in parallel, resulting in loss of audio energy and heavy transformer primary current.—*Editor)*

## R-C-L BRIDGE

Here is a very handy piece of equipment that can be constructed quite compactly yet may have the precision of a larger laboratory model. In this circuit, we find the bridge method of comparing known against unknown values and reading the ratio of the bridge.

Balance is indicated by minimum shadow on the eye of the 6AB5/6N5 indicator tube. The condition of balance is extremely sensitive due to the high degree of amplification furnished by the 12SK7 plus that of the pentode section of the 70L7.

Direct current necessary for the operation of the amplifier and indicator sections of the set is furnished by the rectifier section of the 70L7 and the bridge is fed with an alternating voltage having a value from 30 to 50 volts. This voltage may be supplied by rewinding an output transformer. The 5,000-ohm wire-wound resistor in the circuit is the ratio arm of the bridge. It should have a linear taper.

RADIO-CRAFT *welcomes new and original radio or electronic circuits. Hook-ups which show no advance on or advantages over previously published circuits are not interesting to us. Send in your latest hook-ups*—RADIO-CRAFT *will extend a one-year subscription for each one accepted. Pencil diagrams—with short descriptions of the circuit—will be acceptable, but must be clearly drawn on a good-sized sheet.*

To calibrate the bridge, it is necessary to have a number of standard resistors, capacitors and inductors. These are placed across the KNOWN posts and the unknown value is connected across the UNKNOWN post. The dial of the potentiometer is calibrated from 0 to 100 and if linear will balance at 50 if known and unknown are equal. After the standards have been selected it is possible to calibrate the dial directly by placing other known values across the UNKNOWN posts and noting the position of the potentiometer R when the bridge is balanced.

Calibrating condensers should be of high quality and have a low power factor.

CAPT. DALE W. COURTER,
*Hamilton Field, Calif.*

## VACUUM TUBE VOLTMETER

A very good vacuum tube voltmeter may be constructed from a high range d.c. ammeter.

The shunt is removed from across the terminals of a Westinghouse 15-ampere d.c. meter. The meter is inserted in the output circuit of a balanced bridge amplifier using two 6L6 tubes. V3 is the actual metering tube and V4 is used to balance out any variations in the plate current of V3 which may be caused by grid or line voltage variations.

The 6SN7-GT is used as a cathode-follower amplifier to isolate the grid of V3 from the voltage range resistors and to prevent changes in grid resistance for each range. V2 is the balancing section of the cathode follower.

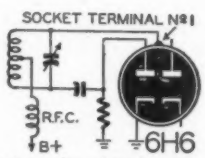
Calibration is obtained by adjusting the meter to zero with the 5,000-ohm wire-wound resistor in the cathode circuit of the 6SN7 and applying known voltages to the input.

Care in the selection of the 2-megohm resistor for the 15-volt range will result in accurate calibration over the entire range of the meter.

LEONARD W. NORRIS,
*Liverpool, N. Y.*

## DIODE OSCILLATOR

For the sake of amusement, the writer suggested the use of the diode tube as an oscillator to a group of radio engineers. Here we are using the term "diode tube" rather loosely. The tube for this circuit is a type 6H6 metal tube, not a 6H6-G or 6H6-GT.

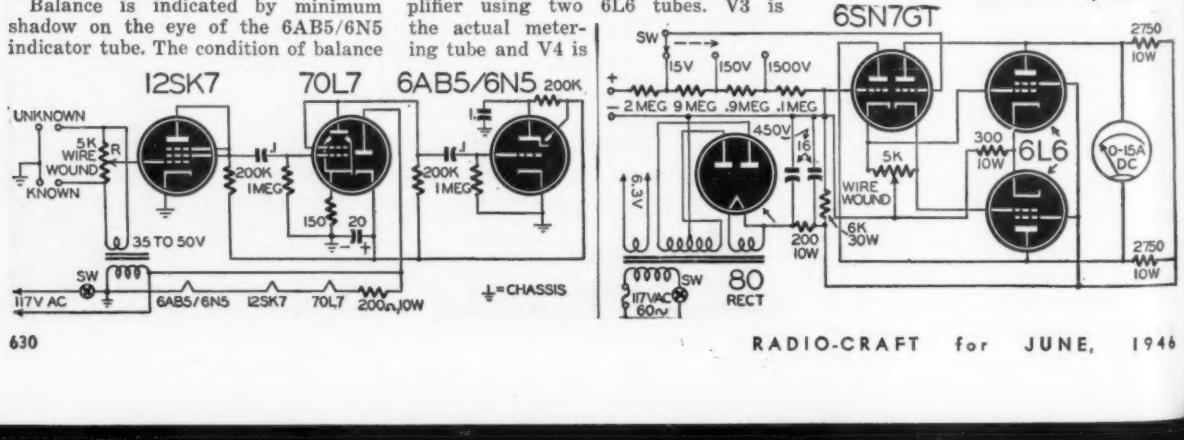



Examining the circuit, you will find that the tube is actually used as a triode. The outer metal shell of the tube is used as a plate and one of the diode plates acts as a control grid. The circuit is quite tricky and may require a little coaxing to produce oscillations.

LEO G. SANDS,
*Towson, Maryland*

(The circuit is interesting, but so far does not appear to have any practical angles. But has Mr. Sands tried to magnetize the shell of his tube and use it as a magnetron? Who knows—he may have a new high-frequency circuit!—*Editor)*

Tube designations were left out of the diagram below. V2 is the left-hand section of the 6SN7, V3 the bottom and V4 the top 6L6.



## NOMOGRAPH CONSTRUCTION

*(Continued from page 629)*

and slide it left till the diagonal line representing 10 coincides with the 1-volt mark on the voltage scale. The cross lines from 2 to 9—representing tenths of a volt—can now be marked off. Move the guide up and mark the scale from 1 to 10, from 10 to 100 and from 100 to 1,000 in the same way.

This nomogram can be used for any problem where two of the quantities given on the chart are known and the third one is to be found. It has range enough to cover most radio needs, but can be extended still further by using the right side of one outside scale against the left side of the other, multiplying or dividing the middle scale by the appropriate number.

### MORE DIFFICULT PROBLEMS

Most nomograms express more complex problems than the simple $IR = E$ just described. A common radio problem is: "With a given amount of current through (or voltage across) a resistor, what is a safe wattage rating?" The mathematical formula is $I^2R = W$ (watts). The difference between this and $IR = E$ is that we have a *power* of a number to contend with. $I^2$ cannot be handled like simple I, but is easy to deal with on a nomographic chart. Multiplication is expressed logarithmically on the chart by simple addition. Powers are expressed by multiplication. The scale for $I^2$ is simply $I \times 2$, or twice as long as a scale for I would be. $I^4$ would be four times as long.

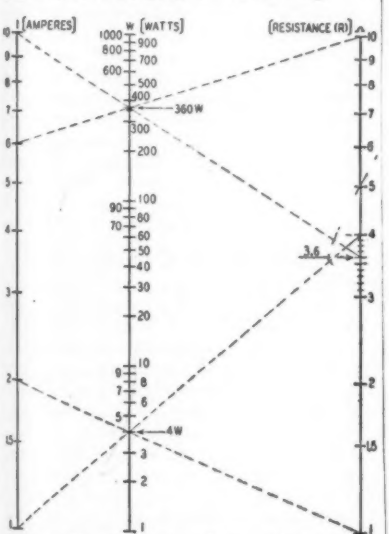



Fig. 4—Placing the "product" scale in graphs which employ roots or powers of the factors.

Nomograms can be constructed with scales of different lengths, but are clumsy. There is another way out of the difficulty. Let us lay out a simple nomogram on 1-cycle paper (Fig. 4), with I and R both running from 1 to 10, in amperes and ohms or any multiple or submultiple. The bottom figure for watt-

*(Continued on page 633)*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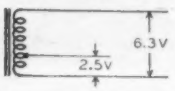
# TRY THIS ONE

## REPLACEMENT

Many times in the past we have been obliged to substitute one tube with another of different heater voltage, such as a 2A5 for a 42. To supply this tube with the required filament voltage we constructed an auto-transformer, using the iron core of a small output transformer. The first 48 turns are fed from




the 2.5 volts supplied by the filament winding of the set and the total of 122 turns furnish the 6.3 volts required by the tube. It is, of course, understood that this may also be reversed so that a 6.3-volt filament supply can be used to operate a 2.5-volt tube.

P. LIVADAS,
*Alexandria, Egypt*

## IMPROVED VOLUME CONTROL

When a receiver using the antenna shunt plus grid-bias type of volume control circuit is tuned to a powerful station, it is often difficult to completely silence the set at the minimum setting of the volume control. This may be cured by connecting a resistor from the "B" plus end of the plate coil to the cathode of the R.F. tube. This causes additional current to flow through cathode biasing resistor thus increasing the bias on the grid.

The value of the resistor will have to be determined by experiment, but wi' probably range between 50,000 and 100,000 ohms. A two-watt resistor is recommended in this revised circuit, as considerable current flows when the volume control is in such a position as to connect its lower end to ground direct.

H. A. NICKERSON,
*Dorchester, Mass.*

## COLOR SCHEME

In using the so-called Spintites, a serviceman usually has to dig through his tool box to select the proper size. There are invariably eight drivers to a set. The only identification one has is a small stamp on the handle denoting the size. I overcame this difficulty by dipping the handles in lacquer, using various colors. Red, yellow, and black may be used for the more popular sizes as the colors are dominant; other colors may be selected to dip the remainder. After becoming accustomed to the color scheme, much time may be saved in reaching for the proper size at a glance.

DAN W. DAMROW,
*Chicago 32, Ill.*

(This scheme is now in use by various manufacturers as standard practice.—*Editor)*

## MIDGET CONDENSERS

In wiring many of the midget radio sets valuable space is taken by paper condensers. Since one-third to one-half the bulk of the condenser is not essential to proper functioning, space may be saved by removing the outer cover and the wax from the ends. The foil is then dipped in melted wax or paraffin so that a thin layer is deposited on the outside.

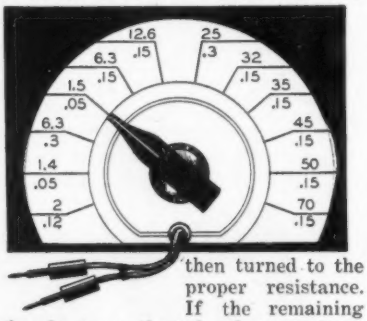
ALBERT PARKS, JR.,
*Cannelton, Indiana*

## TUBE BURN-OUT LOCATOR

Here is a simple method of locating burned out filaments in an a.c.-d.c. receiver.

I took a 500-ohm wire-wound volume control and used an ohmmeter to mark off resistances equal to the resistance of the various types of tubes. Two flexible leads were fitted with phone tips and connected to the control.

When trying to locate a burned out filament in a series circuit, a tube is removed from its socket and the tester tips inserted in the filament holes of the socket. The dial of the locator is



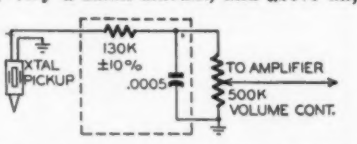

then turned to the proper resistance. If the remaining tubes heat up, the tube that you have removed is the bad one.

WRAY WYCHOFF,
*Ingleside, Nebr.*

(The resistance of a tube filament may be computed by dividing the operating voltage by the current. Thus a 6.3 volt, .3 ampere tube will have a resistance of 21 ohms. Resistor should be in "high" position when plugging in.—*Editor)*

## PHONO SCRATCH FILTER

Here is a favorite scratch filter circuit of mine which uses no hum-collecting chokes, reduces high frequency response by only a small amount, and above all,

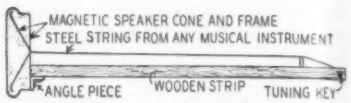



eliminates a great percentage of record surface noise.

GERALD J. WALSH,
*St. Boniface, Manitoba*

## LOUD SPEAKING GUITAR

An old magnetic speaker can be converted into an interesting one-string guitar. The magnet and coil are removed from the speaker, leaving only the armature and stylus attached to the cone. The armature is attached firmly to a strip of wood.




The length of the wooden strip will depend upon the length of the string used. One end of the string is fastened to a tuning key and the other to the speaker armature. When the string is plucked, the cone will vibrate and act as a sounding board for the instrument. Volume depends upon cone size.

JOHN HAYNES,
*Doe Run, Mo.*

## MULTIMETER ACCESSORY

One of our handiest gadgets is a 16-μf, 450-volt electrolytic condenser mounted in each of our multimeters, with the negative lead connected to the negative pin jack, and the positive lead to the positive pin jack, through a toggle switch. When checking voltages, a snap of the switch throws in a condenser which is known to be good, and any increase in voltage reading is clear indication of an open or partly open filter. Since the charge quickly leaks off through the meter, this eliminates the annoyance of accidentally coming in contact with a "hot" condenser, as frequently happens when a loose condenser is used to bridge across a suspected unit.

ARTHUR S. SIMON,
*Armor Radio Service,*
*Miami, Florida*

## CONDENSER CALIBRATOR

With a few alterations, a signal generator may be used to calibrate condensers whose value is unknown.

Leads are brought from the ground and grid ends of the broadcast coil of the signal generator and connected to binding posts that are mounted in a convenient place on the panel.

Condensers are calibrated by tuning the generator to the low frequency end of the broadcast band. This signal is tuned in on a nearby broadcast receiver. Condensers of known value are connected across the binding posts. Tune the frequency control of the generator until the signal is again heard on the receiver. The frequency difference between the two settings of the tuning dial is noted along with the value of the condenser being used.

Condensers from .00001 to .00025 may be calibrated by this method.

AUGUSTINE MAYER,
*Tiffin, Ohio*

## NOMOGRAPH CONSTRUCTION

*(Continued from page 631)*

age will be $1^2 \times$ or 1 watt, and the top figure $10^2 \times 10$, or 1,000 watts. Thus the center scale will have 31 cycles instead of 2 as in the straight multiplication charts.

But it will *not* be in the center. To locate this scale, we have to compute a few wattages, choosing them so the lines on which they lie cross at a broad angle. We can try 4 watts as a first attempt. This is $1^2$ amperes $\times$ 4 ohms, or $2^2$ amperes $\times$ 1 ohm. Draw both lines, as shown in the figure. Then find a similar point near the top of the scale, say, 360 watts. This is $6^2$ amperes $\times$ 10 ohms, or $10^2$ amperes $\times$ 3.6 ohms. Drawing these two lines to locate the 360-watt point, we find it directly above the 4-watt intersection. A vertical line can be drawn through the two points and calibrated in 3 cycles from 3-cycle paper or the diagonal guide.

Nomogram B, shown on page 628, is suitable for calculating safe dissipation for all bleeder resistors and line cords. Note that a safety factor of 100 percent is allowed. If 20 watts is required, use a 40-watt resistor. The scales are 100 to 10,000 ohms and 10 milliamperes to 1 ampere. The watts scale would normally have six cycles, but since we are not often interested in wattages greater than 1,000 and less than 0.1 watt, only four cycles are drawn. The watts scale is located as in Fig. 4, the 1-watt and 100-watt point being particularly convenient to locate. Easiest way to make this nomogram is to draw the outside lines 20 inches long and use a piece of 3-cycle paper to calibrate the watts scale.

Many other radio problems are capable of easy and continuous solution with nomograms. Part II of this article will describe constructions where reciprocals, square roots and additional constant factors are included in the problem, and will give nomograms for resistance of wires $R = kl/C.M.$ and for inductance and capacity required to tune to a given frequency $f = 1/6.28\sqrt{LC}$.

●

## URANIUM A PROTECTOR

Deadly radiations from the uranium-made atomic bomb may be stopped short by shielding with glass containing the same mineral, Professor Alexander Silverman of the University of Pittsburgh revealed last month.

"Strange as it may seem," he said, "uranium, which is used indirectly in atomic bomb manufacture, produces a glass which is probably the best protection we have against powerful X-rays and other harmful radiations. In post-bombing rescue work, uranium or lead spun-glass garments and helmets lined with these glasses in plate form will permit safe entry into the bombed area. Oxygen respirators will be equipped with glass-insulated high-frequency precipitators to keep radioactive dust out of the lungs of the rescue squads."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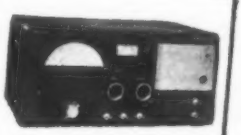

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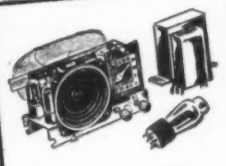

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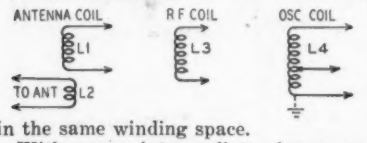
**The Question Box is again undertaking to answer a limited number of questions. Queries will be answered by mail and those of general interest will be printed in the magazine. A fee of 50c will be charged for simple questions requiring no schematics. Write for estimate on such questions as may require diagrams or considerable research.**

## COILS FOR FM RADIO

**?** *I am building an FM receiver using 4.3 mc i.f. stages and covering the 40 to 50 and 88 to 108 mc bands. I want to use a tuned r.f. stage preceding the mixer. My tuning condensers have 32-μμf maximum capacity and 3.3-μμf minimum capacity. Please print coil winding data for the coils to be used in this receiver.—J.W., Tripp, S. D.*

**A.** The coil table below has been prepared for you. Due to stray capacitances and other factors, it will be necessary to do a little experimenting with the coils to get the exact range, pushing the coil turns together, pulling them apart or adding or subtracting one or two turns




in the same winding space.

With your intermediate frequency, there will be considerable image trouble on the higher band, and re-design of the receiver should be considered.

The tap on L4 may be varied slightly to obtain best oscillation under your conditions. All coils are wound with No. 18 enamel wire on ½-inch diameter low-loss forms.

40 to 50 mc

L1—10½ turns spaced to 1½ inch.
L2—3 turns wound ⅛ inch from ground end of L1.
L3—Same as L1.
L4—11 turns spaced to 1½ inch. Tapped 2 turns above ground.

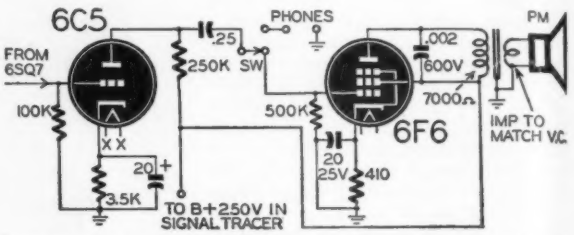
88 to 108 mc

L1—4¾ turns spaced to 1½ inch.
L2—3 turns close wound to ground end of L1.
L3—Same as L1.
L4—5½ turns spaced to 1½ inch. Tapped 2 turns above ground.

## TRACER OUTPUT STAGE

**?** *I have a signal tracer built after one of your printed circuits. This ends with a 6SQ7 and headphones. I would like to add a speaker to this tracer. Will you please show me how to do so?—E.D., Salt Lake City, Utah.*

**A.** The circuit shown will adapt your tracer to loudspeaker operation, or may be used as an amplifier stage on any small radio receiver. The s.p.d.t. switch may be omitted if no phone connections are wanted. Output transformer for a 6F6 may have a 7000-ohm primary and a secondary to fit the voice coil used. Choice of tubes is, of course, very wide, and almost any triode voltage amplifier and pentode power output tube will work well in the circuit.



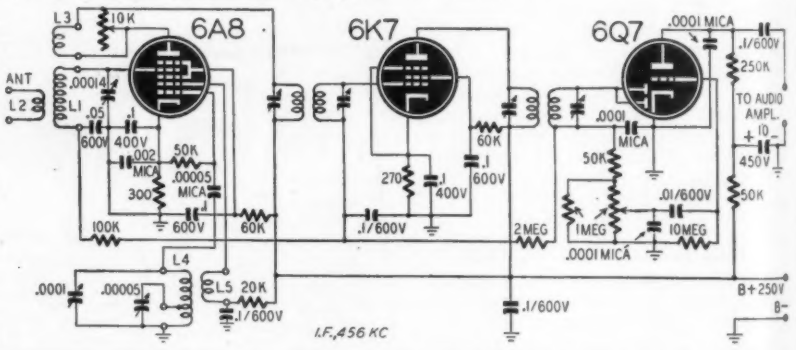

Filament connections are for the power supply of your tracer. For use as an amplifier or for other applications where a heavy enough transformer is not available, a filament transformer might be needed, or a 6C5 and 25L6 (or 25A6 or 43) may be used with a 270-ohm line cord.

## SUPERHETERODYNE TUNER

**?** *Please print a diagram, with coil data, of a three-tube superhet tuner using a 6A8, 6K7 and a 6Q7. I would like to use plug-in coils with four or five prongs and get full coverage from 500 kc to 25 mc. I want to use 140-μμf tuning condensers with a small band-spread condenser across the oscillator coil. I have a power supply giving 250 volts.—C.V., Franklin, Tenn.*

**A.** This diagram is designed to meet your needs as specified. The oscillator coil uses a tapped winding so a five-prong coil must be used in this circuit. If you desire to use regeneration in the first detector stage, L3 must be included. This will require a six-prong form. If this feature is omitted, a four-prong form may be used.

A complete coil table is printed below. Coils for the longer wave-bands may be close-wound, others should be spaced as stated.




| RANGE | L1 | | L2 | | L3 | | L4 | | L5 | | L4 TAP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | TURNS | WIRE SIZE | TURNS | WIRE SIZE | TURNS | WIRE SIZE | TURNS | WIRE SIZE | TURNS | WIRE SIZE | TURNS FROM BOTTOM TO TAP |
| A— 500 TO 1000 KC 300–600 METERS | 195 | N° 32 ENAM | 40 | N° 32 ENAM | 40 | N° 32 ENAM | 127 | N° 32 ENAM | 33 | N° 32 ENAM | TOP |
| B— 900 TO 1800 KC 160–325 METERS | 110 | N° 28 ENAM | 26 | 32 | 26 | 32 | 75 | 28 | 16 | 32 | TOP |
| C— 1700 TO 3300 KC 90–170 METERS | 60 | 28 | 13 | 22 | 15 | 22 | 56 | 28 | 14 | 22 | 40 |
| D— 3. TO 6.4 MC 47–100 METERS | 33 | 22 | 8 | 22 | 11 | 22 | 30 | 22 | 10 | 22 | 20 |
| E— 6. TO 12. MC 26–50 METERS | 18 | 22 | 4 | 22 | 8 | 22 | 16 | 22 | 8 | 22 | 7 |
| F— 10. TO 25. MC 14–30 METERS | 8.5 | 18 | 4 | 22 | 6 | 22 | 8 | 18 | 5 | 22 | 3 |

*L3 IS JUMBLE WOUND TO 3/4" DIA. AND PLACED INSIDE NEAR BOTTOM OF L1.*
*L2 & L5 ARE CLOSEWOUND AND SPACED ABOUT 1/8" FROM BOTTOM OF L1 & L4.*
*PLUG-IN COIL FORMS 1-1/4" DIA.*
*L1 & L4 SPACED TO 1-1/2" ON BANDS A, B, C, D, E.*
*" " " " " 1" ON BAND F.*

## MATHEMATICS, RADIO TOOL

*(Continued from page 617)*

Working *from the bottom tap upward*—

$$R_3 = \frac{E_3}{I_3} = \frac{50}{.005} = 10{,}000 \text{ ohms}$$

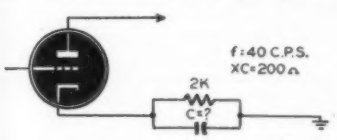
$$R_2 = \frac{E_2 - E_3}{I_3 + I_2} = \frac{100 - 50}{.005 + .010} = 3{,}333 \text{ ohms}$$

$$R_1 = \frac{E_1 - E_2}{I_3 + I_2 + I_1} = \frac{250 - 100}{.005 + .010 + .015} = 5{,}000 \text{ ohms}$$

No matter how many tapped resistors are used, we begin from the bottom and work upward as illustrated.

### CATHODE CONDENSERS

In designing an amplifier, the designer has to solve many factors. For instance, what value of cathode by-pass condenser is necessary for an amplifier with an approximately flat response down to 40 c.p.s. with a cathode resistor of 2,000 ohms? The reactance of the condenser is to be one-tenth of that of the cathode resistance (Fig. 4 below):




Using the formula: $C = \frac{1}{6.28 f X_c}$

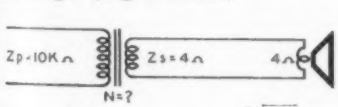
Where C = value of condenser in *farads*, f = frequency in c.p.s., and $X_c$ = reactance of condenser (in this example, its value will be 2,000/10, or 200 ohms):

$$C = \frac{1}{6.28 f X_c} = \frac{1}{6.28 \times 40 \times 200} = 0.00001994 \text{ farads}$$

or approximately *20 microfarads.*

### OUTPUT TRANSFORMER MATCHING

The primary winding of a particular output transformer has an impedance of 10,000 ohms. The technician wishes to place a speaker with a voice coil of 4 ohms across the secondary of this transformer. What ratio should exist between the number of turns on the secondary and primary windings, to provide proper matching? (Fig 5 below.)




Using the formula $N = \sqrt{\frac{Z_p}{Z_s}}$

Where N = number-of-turns ratio, $Z_p$ = the impedance of the primary winding, and $Z_s$ = the impedance of the secondary winding.

Then, substituting—

$$N = \sqrt{\frac{Z_p}{Z_s}} = \sqrt{\frac{10{,}000}{4}} = 50{:}1$$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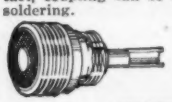
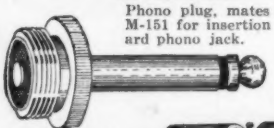
**MODEL M-151**
Female connector. Solid silver plated contact, coupling can be removed completely for soldering.

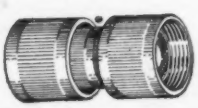
**MODEL M-161**
Chassis mounting, solid silver plated contact. Milled flat, prevents turning in chassis.



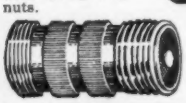
**MODEL M-150**
Phono plug, mates M-150 or M-151 for insertion in standard phono jack.



**MODEL M-192**
Solid silver plated contacts double female with coupling nuts.



**MODEL M-190**
Solid silver-plated contacts double male, mates M-151 or M-150.



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**MODEL M-160**
Chassis mounting—standard solder contact.

**MODEL M-191**
Double female coupling mates M-170, M-160-161.

**MODEL M-150**
Standard solder contact mates with models M-170, M-161, M-160.

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## BETTER BROADCAST TUNER

*(Continued from page 610)*

serious distortion. Second, it may be advanced almost to the point of oscillation to provide high sensitivity and greater selectivity so that two adjacent powerful stations may be separated.

The detector is of the so-called infinite-impedance type, which has many advantages. It has very low distortion, which makes it particularly adaptable for high fidelity reception. Its low output impedance is not affected by shunt wiring capacities, so the high audio frequencies are not attenuated.

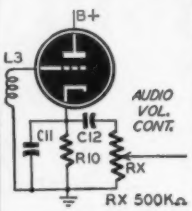


Fig. 2—How a volume control would be added to the circuit.

The output is taken from the cathode through a coupling condenser to keep the d.c. drop across the cathode resistor from biasing the first grid in the amplifier.

The wiring is straightforward, the heaters being wired first and then the grid and plate leads, care being taken to keep them short and well apart.

When the unit is finished it should be connected by means of the terminal strip shown in Photo D to 6.3 volts at 1½ amperes and 250 volts at 25 milliamperes. An amplifier should be connected to its output and turned on. The unit should have an outside antenna if it is to be used at some distance from a station. In the city you may use 20 feet of wire run under the rug, though an outside aerial will more than pay for itself by improving the signal noise ratio.

Turn the dial until a station is received. If no station is heard, then adjust the trimmers, listening to the noise level with the sensitivity control advanced full. When a station is heard, adjust the trimmers until it is at its maximum loudness. Start with the detector trimmer and work toward the one on the first r.f. stage. That done, turn the condenser all the way out to see if you can tune to a high enough frequency. If a station is heard with the condenser all the way out, turn all the adjustable slugs in the coils clockwise several turns to reduce their inductance. Then readjust trimmer for maximum volume. Turn the condenser to the low frequency end (plates engaged) and readjust slightly. If the position of the trimmers is very different at this end of the condenser, bend the end condenser plates until the trimmer adjustment holds over the whole dial.

A dial of the slide-rule or airplane type would be desirable, but a plain knob and pointer may be used with a Bristol board scale. The frequencies may be penned in with India ink.

Photo D—Terminal strip is seen in back view

The tuner when finished will prove to be well worth the work spent in its construction. The clean sound of the high frequencies and good bass will please even the most critical listener. Parts are not critical, though high-grade components will pay off in any high-fidelity tuner as in no other electronic device. A list of the required parts follows:

*(Continued on page 660)*

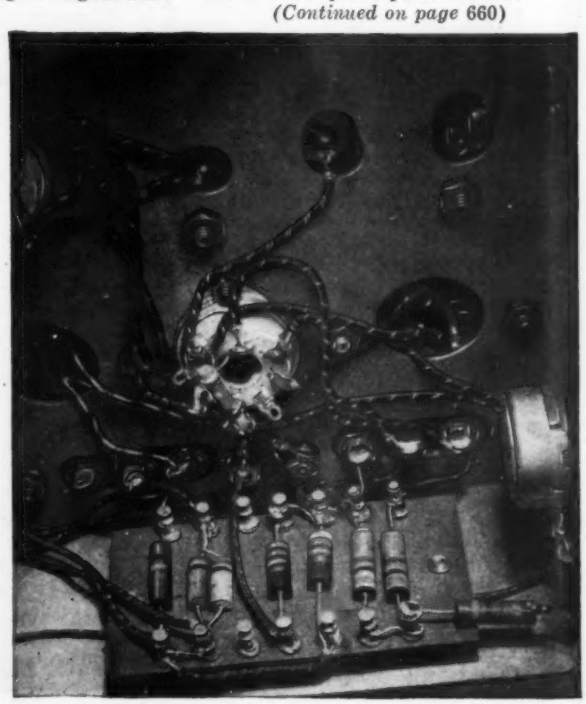

Photo C—How the resistor strip looks in a close-up. This method of attaching the resistors makes for better and more rigid wiring than letting them hang from tube prongs.

## FM CARRIER STABILIZATION

*(Continued from page 606)*

the former reactance, current through the circuit leads the voltage by 90° and therefore the reactance tube circuit is an effective capacitance. Its value depends upon the plate current, which is dependent upon the grid voltage. In other words, the incoming audio voltage controls the size of capacitance which

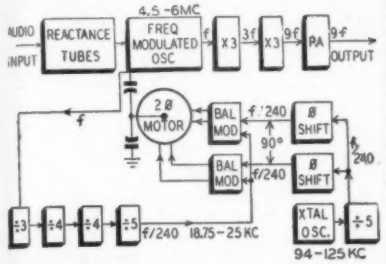


**Fig. 9—Block diagram of the RCA stabilizer.**

shunts the tuning tank and therefore the frequency of the oscillator.

The oscillator frequency is multiplied by 9 in two triplers. This places it in the FM band.

Convenience features the equipment. An oscilloscope is mounted on the control panel so that it can be used to observe the output of each divider to check the lock-in. The same control switch can also be used to connect the scope to either frequency multiplier (in the r.f. section) to adjust it to optimum.

Another selector switch is provided to check the motor action. A d.c. potential

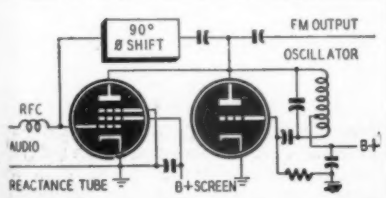


**Fig. 10—Reactance-tube modulation. Control is accomplished by the plate tank condenser.**

may be placed upon the modulator tubes, its value being sufficient to modulate the oscillator over a range greater than that ordinarily encountered due to ambient temperature or line voltage changes. A dial on the motor shaft may be observed to insure that the correction of frequency is as required. If for any reason the motor shaft rotates beyond the normal limits, a buzzer sounds to warn the operator.

●

Radios to the number of 100,000 will be produced in Austria, according to estimates by the government of that country.

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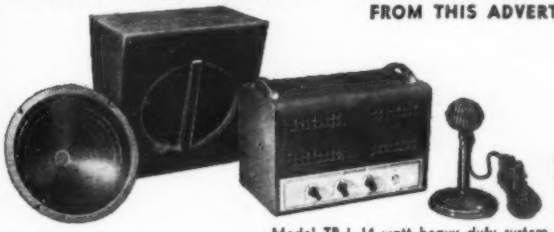

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### 14 WATT AMPLIFIER SPECIFICATIONS

POWER OUTPUT: 14 watts normal
GAIN: Microphone input 110 db.; phono input 70 db.
FREQUENCY RESPONSE: 50 to 12,000 cps, hum —70 db. below rated output.
INPUTS: 1-Microphone, 1-Phono (both high impedance). Separate gain controls for mixing and fading.
TONE CONTROL: Full range bass and treble tone compensator.
OUTPUT IMPEDANCES: 2, 4, 8, 16 and 500 ohms.
TUBES: 1-7C7, 1-7F7, 2-7C5 and 1-5Y4G.
POWER CONSUMPTION: 85 watts, 117 volts 50-60 cycles. A.C. Fused primary.
SIZE: 13"x8½"x8½". Net wt. 15 lbs.

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### 25 WATT AMPLIFIER SPECIFICATIONS

POWER OUTPUT: 25 watts normal
GAIN: Microphone input 112 db.; phono input 70 db.
FREQUENCY RESPONSE: 40-13,000 cps, hum —65 db. below rated output.
INPUTS: 1-Microphone, 1-Phono (both high impedance). Separate Gain Controls for mixing and fading.
TONE CONTROL: Full range bass and treble tone compensator.
OUTPUT IMPEDANCES: 4, 8, 12, 16 and 500 ohms
TUBES: 1-6SJ7, 1-6SL7, 2-6L6 and 1-5U4G
POWER CONSUMPTION: 120 watts, 117 volts 50-60 cycles. A.C. Fused primary.
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## TELEVISION FOR TODAY

*(Continued from page 604)*

transmitted during this resetting period, the trace would be completely out of place in the image. To eliminate this annoyance, the blanking pulse is employed.

The complete video signal, containing the camera signal and the blanking and synchronizing pulses is illustrated in Fig. 1. This is the form of the signal as it appears at the grid of the cathode-ray *viewing tube*. For each fluctuation of the camera voltage a different voltage is placed on the grid. This determines the number of electrons that pass into the scanning electron beam from the cathode. At the screen, the intensity of the light is a direct function of the number of electrons in the beam. When the line's end is reached, the grid is driven strongly negative, completely preventing any flow of current within the tube. Still under the influence of the blanking voltage, the receiver circuits are subjected to a synchronizing pulse, thereby setting up the beam for the following line. Once this is accomplished, the blanking voltage is removed and the camera signal once again assumes control.

At the end of a complete scanning run, when the beam has reached the bottom of the image, the *vertical* synchronizing pulse is inserted. See Fig. 2. This pulse lasts longer than the horizontal synchronizing pulse because the distance that the beam must travel—from bottom to top of the image—is much greater. It is also important that the horizontal synchronizing system is not permitted to slip out of control during this interval. Hence, the vertical pulse is broken up into a series of shorter pulses that permit control of the horizontal system at the same time. This explains why the vertical pulse is not actually one very long pulse, but rather a number of pulses closely connected, as evident in Fig. 2.

The FCC, in establishing the standards for television broadcasting, has designated the various proportions of the video signal. 75 percent of the total available amplitude of the signal is set aside for the camera variations. The remaining 25 percent is utilized for the blanking and synchronizing voltages. Since the point where the blanking voltage starts represents a point where no electrons reach the fluorescent screen, the name of *black level* has been assigned. Driving the grid more negative, as the synchronizing pulses do, certainly does not cause fewer electrons to reach the screen, since all are cut off at the blanking level. However, to name this region, the term of *blacker-than-black* has been given. (See Fig. 1.) Actually, of course, no such state can exist.

To complete the television program, the transmission of sound must be included. While several schemes exist that permit the transmission of the sound and video signals on the same set of frequencies, the most common practice today is to send each separately. The sound band, however, is placed slightly beyond the upper end of the video band, close enough to permit both to be received simultaneously at the receiver. The necessary 6 mc band is proportioned as shown in Fig. 3. It may seem curious that FM is used for the audio while the video is amplitude-modulated. However, field tests have indicated that this represents the best solution and the practice has been standardized by the FCC.

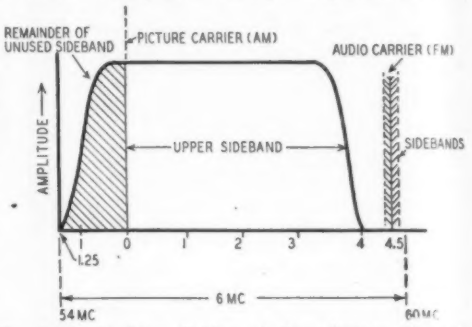


Fig. 3—Audio-video division of the television channel.

Now that we have seen the development of the video signal with its sound companion, let us investigate the arrangement of the circuits in a typical receiver, Fig. 4. A dipole antenna brings the signal down to the input stage.

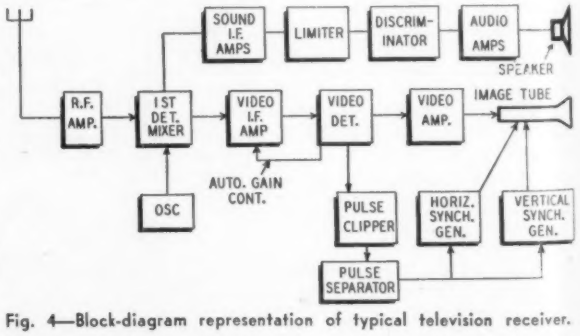


Fig. 4—Block-diagram representation of typical television receiver.

Whether the first stage is an r.f. amplifier or the mixer depends upon the price of the set as well as its location. In localities situated at the outer fringe of the broadcast stations' coverage area, an r.f. stage will probably mean the difference between enjoyable reception

and poor or no reception at all. To be appreciated, a television broadcast must be clearly received. The eye is a critical judge and does not tolerate very much distortion. Random and background noise, to which all radio is subjected, combine with weak signals to produce an image covered with white specks. It is the function of the additional amplifier to increase the signal strength to the point where it will completely mask these noise voltages.

At the first detector, a separate oscillator produces a mixing voltage that reacts with the signal to develop the intermediate frequencies. Since the video and audio sections of the television signal have different frequencies, separate intermediate frequencies are produced. The separation occurs directly beyond the first detector, thus enabling us to deal with each signal according to its own characteristics. In addition, an early separation of both signals is necessary to eliminate any possibility of sound voltage reaching the viewing tube. Should this occur, a series of black bands appears on the screen, changing in intensity with the variations of the sounds.

Investigating the sound channel first, we find the usual lineup of stages necessary to transform an FM signal to its audio counterpart. The limiter removes all amplitude variations in the signal and thus serves as an excellent filter to guard against the trespassing of any video voltages into the loud speaker. Beyond the discriminator, the high-fidelity audio amplifiers produce enough power to drive a loud speaker. In most commercial receivers, standard broadcast reception is also included. To minimize the number of additional components needed to accomplish this, only an AM tuner is installed. A switch connects the output from this tuner directly into the audio amplifiers and the speaker. The same type of arrangement is possible on the regular FM bands. Thus, at very little extra cost, it is possible to have one cabinet house all three types of receivers.

Returning to the first detector, we find the video signal passing into a circuit much more complicated than the sound network. Aside from the additional pulse and generator stages, even the familiar i.f., detector and video amplifier stages contain many modifications. This is due to the video signal having a bandspread which extends 4 mc. A distribution of this width is needed to convey all the image information, from the very large objects in a scene that can be reproduced by relatively low frequencies to the very small details, which require a much higher frequency. Uniform response for 4 mc in a tuned i.f. amplifier can only be achieved by adequate loading; and this, as we know reduces the gain. To counteract the loss in amplification, we find that one or two i.f. amplifiers are no longer adequate; now as many as four or five

*(Continued on following page)*


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## TELEVISION FOR TODAY

*(Continued from previous page)*

must be included. Again we encounter the same sort of situation in the video stages, the amplifiers between the detector and the image tube. Low- and high-frequency compensation are applied to an ordinary audio amplifier to extend the range of uniform response from 15,000 cycles to 4 mc. This, in itself, alters the appearance of the conventional amplifier.

At the video detector, a second separation of signal occurs. Part of the signal continues to the grid of the viewing tube, while part of the signal is applied to a pulse clipper stage. Here the horizontal and vertical synchronizing pulses are clipped off from the signal and directed to a pulse separator network. After separation, the pulses are used to control their respective synchronizing generators. The generators form saw-tooth voltages (or currents) and by applying these voltages to deflection plates (or coils), the proper scanning action of the electron beam can be achieved. In practice, the generators operate as continuous oscillators, with the incoming synchronizing pulses triggering them off slightly before the start of their natural cycle. Thus the units are forced to keep in step with the received signal.

The video portion of the television signal is amplitude modulated and as such is subjected to all the disturbing influences of this form of modulation. For this reason automatic gain control is generally incorporated to prevent the intensity of the reproduced image from fluctuating too noticeably.

## HIGH-POWER U.H.F. TUBE

*(Continued from page 608)*

amplifier is the coupling system, shown in Fig. 1. This is a combination of straight resistance coupling and the old d.c. amplifier circuit. The video stages

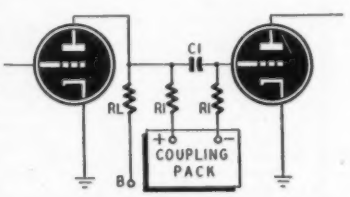


Fig. 1—The all-frequency coupling circuit.

are coupled together through an ordinary blocking condenser, the ends of which are connected through isolating resistors to the terminals of a regulated power supply, referred to as a coupling pack. This results in the higher-frequency video signals—which are most liable to attenuation by the by-passing effect of the pack's capacity to ground—being passed through the condenser. The isolating resistors (RI) are made very much larger than the first stage load resistor (RL) so the capacitance of the coupling pack does not shunt the high frequencies.

At lower frequencies, where the coupling condenser would offer considerable reactance, both terminals of the coupling pack are raised or lowered in voltage by the same amount as the plate of the first stage, transferring the signal to the second stage through a path consisting of the isolating resistors and the pack itself. The region of transfer of signal from one path to the other is gradual and smooth, and the amplifier response is uniform from high video frequencies to d.c.

Three video stages, using respectively a 6AG7, an 807, and two 807's in parallel, are followed by the first 6C22 (fourth video stage). With an input of 180 volts and a gain of 3.5, it puts out a signal of 700 volts.

The next stage—the final modulator—is a cathode follower using two 6C22's. The cathode-follower circuit is employed because it supplies a driving source of low impedance which, with the negative feedback characteristic of the circuit, tends to preserve a flat frequency response in spite of the shunt capacitance of the r.f. amplifier load.

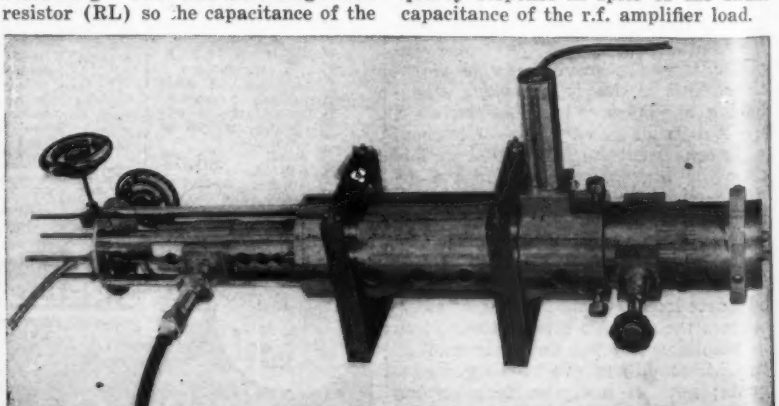

Photo B—A coaxial amplifier using the 6C22 tube, designed to operate at 490 megacycles.

## A PORTABLE INTERCOM

AN intercommunication unit, portable-style, is one of the first gadgets to burst upon the postwar market. It contains a five-inch PM speaker with a voice coil matched to a carbon-ball mike, a double-throw single-pole switch, and a pair of dry cells. All component parts are housed in a tent-shaped metal cabinet with two grills cut into the face; one for the mike and one for the speaker. The switch is a slide type and is mounted between the mike and speaker openings.

The hookup is basically simple as shown in Fig. 1. The carbon-ball mike was used for greater sensitivity as it is doubtful whether a carbon-granule microphone would be sufficiently sensitive to operate the PM speaker.

An additional advantage of this unit over other communicators is that it is portable to some extent. It can be used in the open field for a distance of about 120 feet with little loss of volume, and since it does not depend on an external source for power, it can be quickly set up from apartment to roof for example, when adjusting FM or television antennas. Location of such aerials with respect to the transmitting antenna and to possible sources of "ghost" responses is important. Many schemes have been tried to get best polarization, ranging from the use of a complete radio transceiver installation between receiver and roof to simply trying the set a few days, rotating the antenna a few degrees, and trying again. This intercommunicator offers another practical solution of the problem.

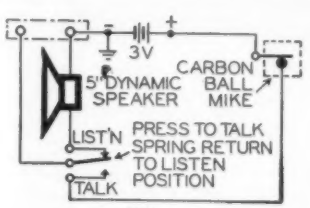


FIG. 1

When not in use, the batteries are not being drained. When one party presses the switch to the "talk" position, the batteries of the "talker's" unit operates the speaker of the "listener's" unit. The reverse occurs when the "listener" talks.

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## CORRECTION

The article "Dummies Save Tubes," which appeared in the March issue, page 437, contained an error in the placement of the drawings. The positions of the two drawings at the bottom of the page became reversed in the printing processes. The drawing on the left, having two 28-ohm resistors connected in series between pins 2 and 7, should have been placed over the caption: "(c) dummy for 3Q5" and the drawing with the 14-ohm resistor connected between pins 2 and 7 should have been placed on the left of the column over the caption "(b) —0.1-ampere dummy."

Our thanks to Mr. Marcus H. Moses of New York City for calling this error to our attention.

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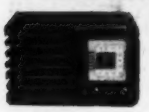

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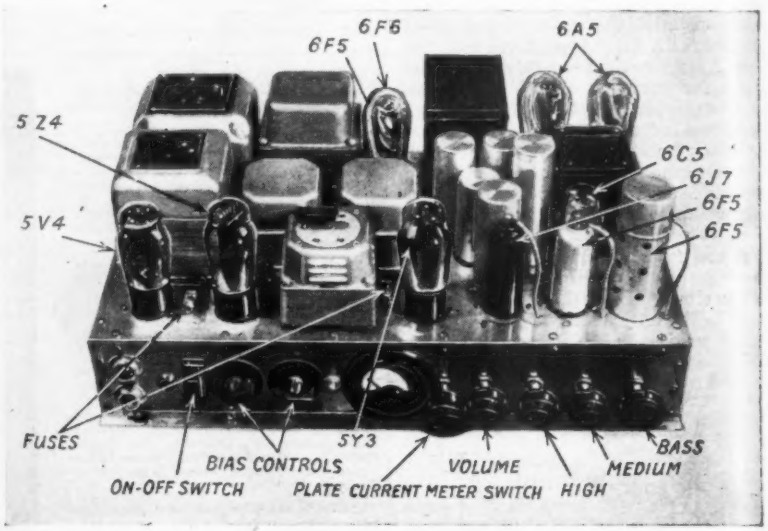
## THREE-CHANNEL AMPLIFIER

*(Continued from page 607)*

On the other hand, we will devote more time and details to the interesting and unusual features of the amplifier.

The 1-megohm resistors R1 and R2 isolate the three inputs from each other, preventing a mutual short-circuit. The condenser C1 has as its object the short-circuiting of the high and medium notes for its particular input. Therefore the 6F5 stage at the top of the schematic is the "bass" pre-amplifier. Its gain is regulated by the volume control P1. The condenser C2 prevents basses from reaching the grid of the 6F5 directly below the "bass" input. Therefore, only mediums and highs pass.




But, as we shall see, the highs will be attenuated further on. This stage constitutes therefore the "medium" pre-amplifier, controlled by P2.

The output of these two stages is applied, through a common volume control P4, a 6C5 and a transformer, to a push-pull stage, using 6A5 triodes. Their low internal resistance permits excellent reproduction of the basses. The negative feedback circuit R4, C4 weakens the high notes, the condensers C4 being of low value (50μμf). The output transformer has two windings, the higher potential one being tapped to permit adaption to loud speakers of different impedances. This arrangement—two 6F5's, 6C5 and two 6A5's—constitute the "bass and medium" amplifier.

The low capacity condenser C3 (25 μμf) permits only the highs to pass. To enhance this effect the cathode circuit of the 6J7 is decoupled with a condenser of only 0.1 μf (across 800 ohms) which reduces the bass and medium notes through degeneration.

This stage constitutes the "high" pre-amplifier. Its gain is also independently controllable, by volume control P3. It is followed by a 6F5 and 6F6.

The output transformer feeds a little speaker, of a small diameter intended only for the reproduction of the highs. Under such conditions, this speaker has a marked directional effect. To soften this effect, signals of lower frequencies may be fed (at low level) into the "high" amplifier. This has been done through use of the resistor R.

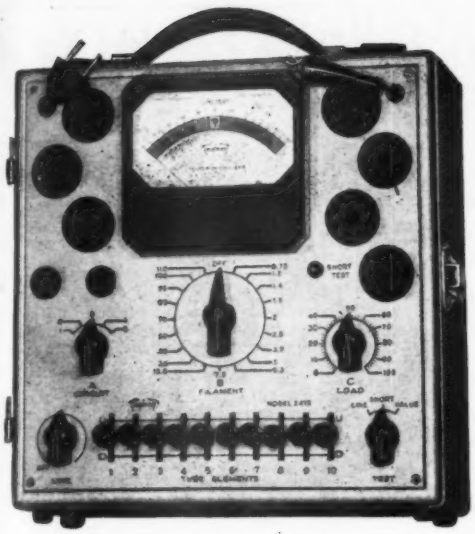
Let us note also the milliammeter which permits rapid comparison of the plate currents of the 6A5's, or measurement of the total plate current of the two; a feature which facilitates balancing the push-pull stages and also gives a check on the condition of the amplifier.

Reprinted by special arrangement from *Toute la Radio*, Paris, France.

## RADIO-ELECTRONIC QUIZ

*How thoroughly have you mastered the contents of this magazine?*
*Try the following quiz as a test:*

1. How does a radio wave react when focussed by a metal lens? See page 602.
2. What is a television blanking pulse? See page 604.
3. What is a nomogram and how is it used? See page 609.
4. Can quartz crystals be used as superheterodyne oscillators? See page 611.
5. What is the band-width of a video amplifier? See page 613.
6. How do radio-frequency power supplies work? See page 616.
7. How would you design a voltage divider? See page 617.
8. What is the width of a television channel? See page 638.
9. What is a two-dimensional radio? See page 643.
10. What is the difference between a sniperscope and a snooperscope? See page 651.



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- Sockets: One only each kind required socket plus one spare.
- Distinctive appearance makes impressive counter tester.

*Precision first ...to last*

**Triplett**

**ELECTRICAL INSTRUMENT CO.** BLUFFTON, OHIO

# TWO-DIMENSIONAL RADIOS

RECENT war-time developments in electronic circuit technique make it possible to virtually "print" a highly efficient circuit, complete with wiring, resistors and condensers, upon a ceramic plate. Batteries and tubes are soldered to the printed circuit to complete the assembly. The new development was announced in the April issue of this magazine.

The new process, developed by Centralab engineers, uses the silk screen method to apply "silver ink" to the ceramic surface. The "ink" hardens to produce a silver conductive circuit instead of the usual copper wire.

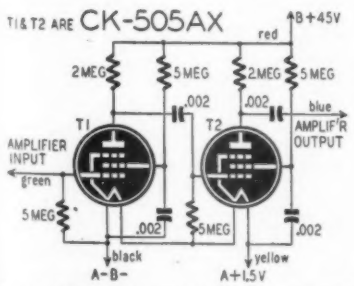



Fig. 1—Circuit of amplifiers in the photos.

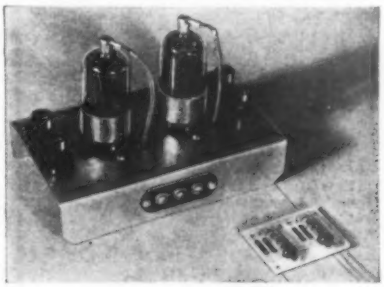
Figure 1 above shows the diagram of a conventional two-stage amplifier circuit, using "hearing aid" tubes. This amplifier was used in the famous proximity fuze. In developing a technique for rugged miniature wiring circuits, for this application, the engineers came up with the "two-dimensional wiring" technique. This development makes possible unbelievable reductions in the physical size of a radio circuit. To illustrate the drastic reduction in size, Photos A and B, contrast the conventional assembly of Fig. 1 and the same circuit with the newly developed technique.

The smaller circuit is conspicuous by the apparent absence of condensers and resistors. The resistors are the small black lines which appear at the left of the tubes. They are made by screening a heavy paint, containing a large proportion of finely divided carbon onto the surface. The resistance is regulated by the length, width and chemical composition of the printed lines. Using this method, resistors ranging from 3 ohms to 200 megohms have been produced. A resinous coating is applied to the resistor to protect it from the effects of moisture, thus making it stable under all conditions.

The condensers are made from thin ceramic discs plated on each side with silver (Photo B). The capacity varies directly as the area of the plating and the thickness of the discs. It is possible to produce condensers by this method that vary in capacity from 6.5 μμf to .002 μf.

Special solder must be used for connecting power leads and tubes into circuit. A solder having at least 2 percent silver content must be used to prevent the absorption of silver ink from the surface of the plate. A low-temperature bismuth solder is used to fasten the tiny silvered capacitors to the silver leads because the heat used with normal solders would fracture the ceramic discs.

*(Continued on page 647)*



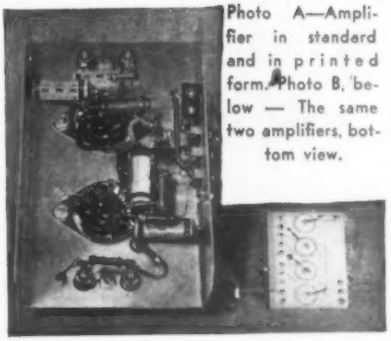


Photo A—Amplifier in standard and in printed form. Photo B, below — The same two amplifiers, bottom view.

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## TECHNOTES

**. . . . LOW RESISTANCE LEADS**

Save the flat copper "dial cords" from those old Atwater Kent receivers that you junk. Sections from them will make very nice low-resistance, flexible leads for plates and grids, especially for HY615's and HY75's used extensively in WERS transmitters now being converted to 144 mc ham rigs.

B. BUEHRLE, JR.,
*Fergerson, Mo.*

**. . . . EMERSON FU424 AND FU427**

A common complaint of these sets is low plate voltage and loss of filament voltage. The filaments of the 1.4-volt tubes are heated by the cathode current of the 117P7 (pentode section) passing through them.

An open input filter condenser will be found to be responsible for the troubles and will have to be replaced.

STANLEY RUTKOWSKI,
*Erie, Penna.*

**. . . . WESTINGHOUSE M 108, M 112**

When these models are subjected to humid air for a length of time, it will be noticed that the tone quality becomes very bad. This condition is caused by the voice coil coming loose from the speaker cone and may be cured by applying speaker cement freely where the voice coil and cone join.

A. K. MEMON,
*Karachi, India*

(Note that such troubles are more likely to occur in hot humid climates such as the writer's.—*Editor)*

**. . . . ATWATER KENT 46**

A "dead" set may be the result of the voice coil leads on the speaker cone breaking loose from the flexible leads from the output transformer. Checking and resoldering can be done without removing the cone.

B. BUEHRLE,
*Fergerson, Mo.*

**. . . . SPEAKER REPAIRS**

In speaker repairs where it is necessary to remove the paper cone, lacquer thinner, which may be purchased from most paint stores for about fifty cents a quart, may be used. Place the speaker face down in a tin pie plate and fill with thinner to a level that just covers the speaker rim. After soaking about twenty minutes the cone is easily removed.

Many plastic parts that have warped may be straightened by dipping in hot water and bending back to their original shape while flexible. They will retain their shape when cool.

HUBERT WATKINS,
*Gulfport, Miss.*

**. . . . PHONO PICKUP HINT**

I have often had trouble putting a new needle in a phono pickup head. This is especially true of heads that cannot be raised high enough to view the needle hole. Try laying a small pocket mirror under the head and the job becomes an easy one.

HOWARD SCHLIEF,
*Fairfield, Pa.*

## Civilian Radio Jobs Wanted

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# H. F. Wideband Amplifier

POSTWAR video amplifier design is demonstrated in the illustrated compact high-frequency amplifier, manufactured by Sylvania Electric Products, Inc. Supplied for center frequencies between 30 and 70 mc. with any bandwidth from 2 to 10 mc., these sets are designed particularly for use as i.f. amplifiers in u.h.f. and s.h.f. receiver applications.

These units are well worth study by the serviceman and technician, for, with modifications for various applications, they are typical of what will appear in many kinds of high-frequency broadcast, television and communications apparatus.

This is the amplifier whose circuit is shown in the diagram below. It does not differ greatly in appearance from ordinary equipment.

A typical amplifier has an overall gain of 100 db with a center frequency of 60 mc and a half-power bandwidth of 9.0 mc. An external gain control is easily provided. Unless otherwise specified, a standard 500 ohm input impedance is supplied. The output stages are cathode followers designed to operate into impedances of 75 to 100 ohms with voltages ranging from 0.5 to 2.0 volts, negative or positive.

Video amplifier technique appears in the low plate resistors, high-frequency grid chokes, special chokes in the filament circuits and other features readily noticeable on the schematic. Gain per stage is low—thus eleven tubes are required for the 100-decibel gain.

The video detector may take one of several forms according to the special application of the amplifier. In broad-band circuits the frequency characteristics of the rectified video components will be such that the output at 8 mc will be reduced not more than 3 db from the output at 1 mc. These amplifiers will thus pass a square top pulse having a duration of 0.15 micro-second or greater with negligible frequency or phase distortion, making them particularly suited to television receiver applications.

Either single-ended or balanced input circuits are supplied. The balanced input circuits are designed to use with dual input systems and will distinguish between in-phase and out-of-phase signals from two channels. In one such unit this discrimination is 33 db.

The unit, as may be seen from the photograph, differs little in appearance from more conventional apparatus, the only external signs that distinguish it from an ordinary amplifier being the special small chokes.

Power supply for a typical amplifier includes + 105 volts d.c. at 90 ma, + 300 volts d.c. at 20 ma, and 6.3 volts a.c. or d.c. at 1.7 amperes. External gain control requires 0 to −12.5 volts d.c. 1.5 ma.


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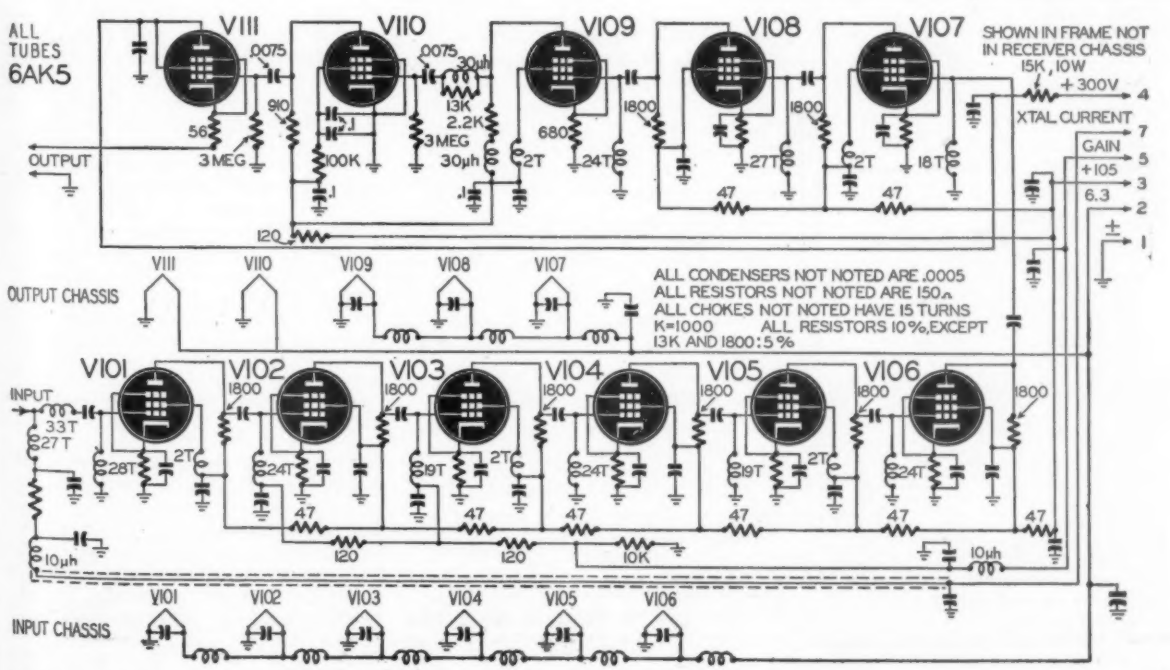

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**On your letterhead (do not use postcards) ask us to send you the literature which you designate. *It is only necessary to give us the numbers.* We will then send your request directly to the manufacturers, who in turn will send their bulletins or other literature directly to you.**

### 224—THE LIGHTHOUSE TUBE

Published by General Electric Company. The story of the new disk-seal electronic tube, known as the "Lighthouse Tube" and its specifications are given in publication ETR-7. This pamphlet describes the basic principles of design and operation of the tube and its advantages in the fields for which it is designed. The tube, now released from war applications, will be applied to television, FM radio and other fields in the ultra-high frequency spectrum.—*Gratis to interested parties*

### 225—THERMOCOUPLE DATA BOOK

Bulletin S2-6, published by Wheelco Instruments Company. A 31-page booklet of data on thermocouples and accessories. Complete with engineering drawings of all types of thermocouples. This data book may also be used as a catalog of the equipment and accessories handled by Wheelco Instruments Co.—*Gratis*

### 226—CANNON CONNECTORS

Sixty-four pages of material on many types of connectors, dust caps and receptacles is available in bulletin "K," published by Cannon Electric Development Co. This bulletin is illustrated and complete with dimensional drawings.—*Gratis*

### 227—SHALLCROSS CATALOG

An eight-page booklet describing the types of precision resistances and decade boxes available from the Shallcross Manufacturing Co. This catalog is of interest to electrical engineers, physicists, and manufacturers of electrical equipment.—*Gratis*

### 228—HIGH VACUUM EQUIPMENT

An interesting catalog by Distillation Products, Inc. Of interest to electronic engineers and physicists. It lists the various types of vacuum pumps and gauges necessary for high-vacuum work.—*Gratis to interested parties*

### 229—OHMITE CATALOG

A 16-page catalog published by Ohmite Manufacturing Company. Lists wire-wound resistors available from 1 to 200 watts with rheostats running to 500-watt capacity. Also included are volume controls, including special types, r.f. chokes and dials.—*Gratis*

### 230—KENYON TRANSFORMERS

A general catalog of transformers manufactured by Kenyon Transformer Co. The transformers listed are those applicable to practically all phases of radio and electronic work. This catalog includes five pages of charts and graphs of value to the engineer or serviceman—*Gratis*

### 231—REED FREQUENCY METERS

Bulletin 1770 contains 16 illustrated pages describing the Frahm Vibrating-Reed Frequency Meter as manufactured by James G. Biddle Co. These meters are manufactured in switchboard, portable and miniature models.—*Gratis*

### 232—LABORATORY OHMMETERS

Precision ohmmeters described in Bulletin 1805, published by James G. Biddle. These instruments are of interest to electrical engineers as well as telegraph and telephone maintenance men.—*Gratis*

### 233—PIEZO-ELECTRIC CRYSTALS

A seven-page catalog, of interest to engineers and amateur experimenters, issued by Crystal Research Laboratories, Inc. It describes the various types of crystals developed by the firm. Crystals are available for all applications, including supersonics.—*Gratis*

### 234—ELECTRICAL THEORY

Part 3 of a series on the theory and applications of electronics is published by Kuhlman Electric Co. This well-written booklet is illustrated with vector analysis diagrams of oscillators and other circuits.—*Gratis*

### 235—RECORDING DEVICES

A seven-page catalog, issued by Production Instrument Co. Includes a number of counters which have many applications in production. These counters are made to indicate the number of units or pulses produced as well as the number of revolutions or turns that have been applied to a coil-winding machine. Time totalizers and switches for actuating electric counters are also included in this well illustrated catalog.—*Gratis*

### 236—PLUG AND SOCKET CATALOG

An illustrated catalog of sockets and plugs applicable to radio and electronic equipment, published by A. W. Franklin Manufacturing Company. The illustrations of sockets and plugs are accompanied by working drawings and descriptive material.—*Gratis to interested parties*

## TWO DIMENSIONAL RADIOS

*(Continued from page 643)*

In actual construction, the resistors are printed on one side of the plate and the condensers are wired to the other. Fig. 2 shows the method of connecting the portions of the circuit on opposite sides of the plate. For clarity, the parts have been drawn in symbolic form between the connecting points.

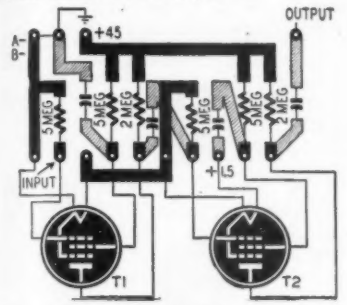


Fig. 2—"Wiring Diagram" for printed radio.

This new method of circuit design makes it possible to print *coils* for ultra-high-frequency circuits directly on the plate. Such coils have a Q of 150 to 200.

Although this technique is not applicable to the production of complete receiving or hearing aid sets, it may well be applied to unit portions of the circuits, such as resistance coupled amplifiers and simple control circuits. The small units may be replaced in a defective circuit almost as easily as a tube is changed today. The effects of this type of construction may soon be seen in smaller radios and hearing aids which will be more reliable and more easily serviced than the best sets today.

## R.F. POWER SUPPLIES

*(Continued from page 616)*

lished in the *Proceedings of the I.R.E.* April 1943. Sylvania pointed out the possibilities of such a circuit in connection with their 28D7, a tube intended to work with a plate voltage of 28 to 32. (*Sylvania News*, Jan, 1944.) Curves showing an output voltage as high as 200 (at 1 milliampere) and currents as high as 6 milliamperes (at 100 volts) were shown; plate input in each case being 28 volts. An article on this type of power pack appeared in the August, 1944 issue of RADIO-CRAFT, with a 25A7 instead of the 28D7 which was not easily obtainable, at least at that time.

There would appear to be definite field for power supplies of this type in a number of applications where moderate current is required, whether the voltage be high or low.

●

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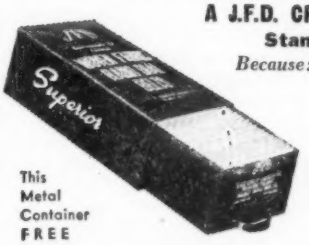


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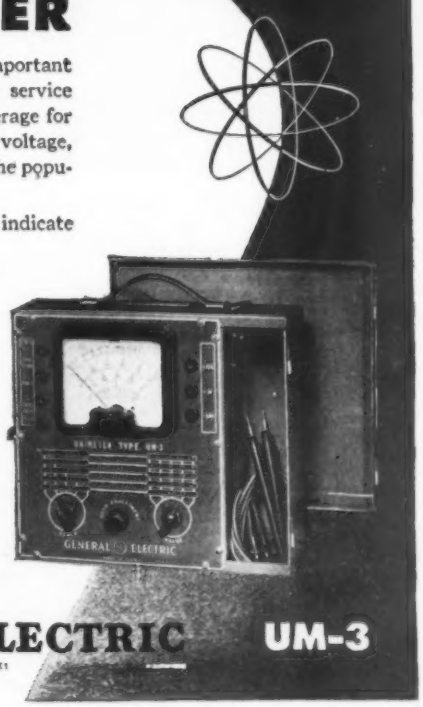
For details write: *Electronics Dept., Specialty Division, General Electric Company, Syracuse, New York.*



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## REDUCING HUM LEVELS

*(Continued from page 619)*

The speaker field resistance in Fig. 2 might be, in many cases, 400 to 500 ohms. If a low resistance choke having a d.c. resistance of 80 or 100 ohms is put in the circuit, as shown in Fig. 3, the d.c. voltages will not be affected to any considerable extent but the hum level will be greatly reduced. The choke alone will help in reducing hum, but if an extra filter is added, $C_3$, which may be 16-μf, the hum will be still lower.

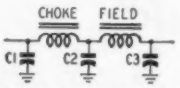


Fig. 3—A low-resistance choke will cut hum.

In a.c. sets using full wave rectifier power supplies, the hum output of the B supply may be very low since the ripple frequency is 120 cycles and the filtering can be made efficient. The hum due to an unbalanced filament circuit may then be more important. In Fig. 4, a tap is used on the filament winding and may give satisfactory results with such tubes as the 45, 47, 2A3 and 6A3. An improvement will sometimes be possible if a centertapped resistor or a potentiometer arrangement is used. In Fig. 5, the use of a potentiometer is indicated, permitting an electrical balance in the filament circuit.

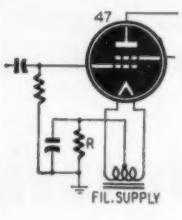


Fig. 4 (left)—Hum may arise from an off-center transformer tap in older receivers.

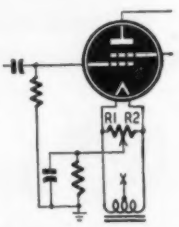


Fig. 5 (right)—The centering resistor was well known as a "humdinger" in its heyday.

In many sets, a push-pull output is used. A common cathode resistor is employed and no attempt is made to get a good balance in the output stage—essential for minimum hum and distortion. By using separate, adjustable resistors, as shown in Fig. 6, the balance and correct bias voltages are obtained. The maximum resistance of each bias resistor, that of $R_4$ or $R_5$, would be about twice the value of the original cathode resistor. $C_6$ and $C_7$ are not very critical in capacitance values and could be rated at 20-μf and 50 volts each. Condensers rated at 150 volts could also be used. The cathode resistances would be adjusted until equal plate currents, $I_1$ and $I_2$, flowed in the primary of T. The currents would be indicated by low resistance d.c. milliammeters placed in series with each half of the transformer.

### LOW RESISTANCE CHASSIS

The importance of using a low resistance chassis can be seen by referring to Fig. 7. In some sets, one side of the filament winding is grounded to the chassis, say at point 1. The filament of the amplifier tube VT may be connected to chassis ground at point 5 and directly to the winding, C, at 7. If the chassis resistance between 3 and 4 is appreciable, a hum voltage may act in series with the grid of the amplifier tube and be greatly amplified, especially in high-

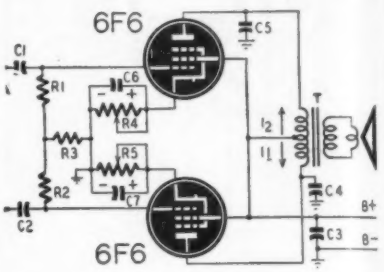


Fig. 6—Individual bias for push-pull tubes.

gain circuits. If the circuit is an r.f. type, hum modulation of the r.f. may result and then the hum will be heard due to the demodulation action of the second detector. By placing the grid return at 3, close to 4, a hum reduction may be found in some cases. Also, running a wire from 1 to 5 may prove helpful, instead of depending on the chassis as a conductor for the filament circuit hum current. Similarly, running $C_1$ not to point 2 but directly to point 1 is good practice. $C_2$ should not go to 6 but to 1. In this way, stray chassis currents can be reduced. Too many servicemen, in putting in a filter condenser, just look around for any old place to hitch the replacement unit instead of giving some thought to the matter. Note that the condensers in the primary circuit of the power transformer should be connected to a common point on the receiver chassis. If they are connected to two different points, hum may be heard.

Another important factor is an equal reading for each plate of the rectifier when testing the tube. The readings should be reasonably close together, a variation of 10% being maximum. If the plate readings are not equal, the rectifier tube should be replaced. An unbalanced rectifier may put out a 60-cycle hum plus harmonics. With the decreased ripple frequency, the filters are less effective and the hum level goes up.

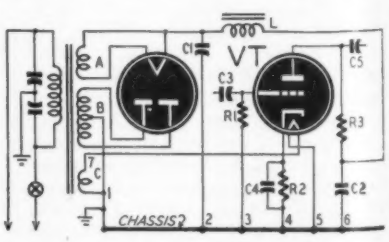


Fig. 7—Grounds to chassis may be important.

## ? ? WHY NOT ? ?

**Have you ever asked yourself, "Why can't I have this or that gadget on a radio? Why aren't programs made to fill such and such a need?" If so, you are a charter member of the *Radio-Craft* "Why Not" club. Send us your "Why Not's" on all subjects—serious or screwball, practical or idealistic. We will pay $1.00 for every one we believe will interest the readers of *Radio-Craft*.**

**You can get the idea from the "Why Not's" printed below. Send in as many as you like. One dollar will be paid for *each one printed*.**

**Why not** have the manufacturers make speaker cones out of a thin plastic material that won't tear?

DAVID STRICKLAND,
*Pensacola, Fla.*

(Some cones already have been made in full plastics, as well as plasticized fabrics. No doubt they will come into general use soon.—*Editor*)

●

**Why not** imbed magnetic wire recordings in paved roads at danger spots and then equip autos with magnetic pickups so verbal warnings and directions can be given?—

E. E. YOUNGKIN,
*Altoona, Pa.*

●

**Why not** have the sound engineers of all the picture-producing companies print the picture sound tracks to the same level? Then the operator in the projection booth would not have to set the amplifier volume control whenever he changes from one reel of the picture to another.

DAVILO R. REYES,
*Gamboa, Canal Zone*

●

**Why not** give us a few articles on cabinet designs? Surely a lot could be said about reaction to heat and audio-frequency response of plywood, ordinary wood, plastics, and metal. Some radio experimenters build their own cabinets as well as what goes into them.

LUDWIG FURTH,
*London, England*

●

**Why not** install home recording equipment in television sets for the purpose of recording a television program's video signal? Then with a flick of a switch whole television programs may be recorded on phonograph records. The voltage fluctuations which affect the electron beam in a cathode-ray tube can easily be impressed on a record, and when the record is played back these voltage fluctuations are reproduced and applied to the plates of the tube. It might also be interesting to play this record of a picture on a regular sound phonograph; then we could *hear* what a picture looks like.

MORTON LUTZKY,
*Brooklyn, N. Y.*

[The wide frequency band required by a video signal (as high as 2½ or 3¼ mc.) cannot be recorded on any existing recording system.—*Editor*]

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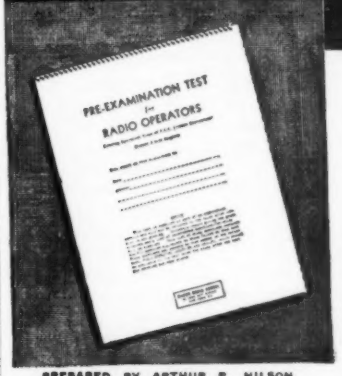


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*Speaker Opening in center of front side.

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## "PORTARIG" HAM STATION

*(Continued from page 612)*

on the power unit to provide a link for the power cord between the transmitter-receiver chassis and the power chassis. As it was desirable to operate the set with the power unit about six feet from the transmitter, remote power switching is available from the panel of the transmitter when d.c. supplies are used. The filament pins of the socket are used to carry the d.c. because they are larger and will offer less resistance to the flow of current. Line voltage is controlled by a switch in the line.

Determining the correct values for the transformer buffer condensers is one of the most difficult tasks encountered in constructing a vibrator-type power supply. An oscilloscope is used to determine the correct wave form of the primary voltage. The ideal wave form that may be reached in practice is shown in Fig. 4-a. Wave forms caused by too much capacity will resemble Fig. 4-b while insufficient buffer capacity will give wave forms similar to 4-c. If an oscilloscope is not available a d.c. ammeter is placed in the battery lead and condensers changed till *lowest* amperage is registered.

"Hash" chokes are placed in the positive lead to the vibrators to prevent vibrator noises from being radiated. These chokes consist of 20 turns of No. 10 enamel wire wound on a ¾-inch form.

**COIL DATA FOR PORTARIG**
**80-METERS**

L1—(r.f. grid coil) 45 turns, No. 24 enamel, close wound.

L2—(r.f. plate coil) 24 turns, No. 24 enamel, interwound with lower end of L3.

L3—(Mixer grid coil) 45 turns, No. 24 enamel spaced.

L4—(power amplifier plate coil) 54 turns No. 16 enamel, tapped at 20 and 30 turns.

Coils L1, L2 and L3 are wound on 1¼-inch forms, L4 is on 2¼-inch form.

Receiver ON-OFF switch, S1 is a heavy-duty double-pole, single-throw switch with the poles wired in parallel. When this switch is closed, d.c. voltage is applied to both vibrators and the receiver filaments. The transmitter ON-OFF switch, S2, is used to control the filament voltage to the transmitter. It is so wired that it is impossible to heat the transmitter filaments without turning on the receiver filaments and the "B" voltage.

The SEND-RECEIVE switch is a heavy-duty double-pole double-throw switch used to switch the antenna from the transmitting to receiving circuits and the phone jack from a.f. output to side-tone reception.

The volume control is a 500,000-ohm potentiometer in the grid circuit of the 6Q7.

The modulation control is a 500,000-ohm potentiometer connected across the grid winding of the input transformer to limit the audio level applied to the 6Z7 grid. This control is not brought out to the front panel since it is pre-adjusted to give full output from the modulator when speaking close to the microphone in a normal speaking voice.

Selection of the a.v.c. and a.n.l. circuits is made by the A.N.L.-A.V.C. switch, S3 which is a two-pole, four-position rotary switch. It is possible to get either type of operation, or both combined, with this switch.

The PHONE-CW switch is a double-pole, double-throw switch, S4. When in the c.w. position, the plate voltage is applied to the plate of the b.f.o. tube and the r.f. power amplifier plate lead is shunted around the modulation choke.

A 4-gang-4 position switch, S5, is the Channel Selector. Sections "A" and "B" select the proper tuning condensers for the antenna and mixer coils of the receiver. "C" and "D" select the crystals for the receiver and transmitter oscillators respectively.

Antenna tuning is accomplished by C1 and C2, which are 100-μμf double-spaced midget condensers. They are connected across the ends of the tank coil, L4, in a "pi" network. The end plate of C2 is bent so that it will short the condenser when the plates are fully meshed. With C2 shorted, the circuit becomes a conventional shunt-fed tank. By using this method of loading the transmitter output circuit any single or double wire antenna may be matched without loading coils.

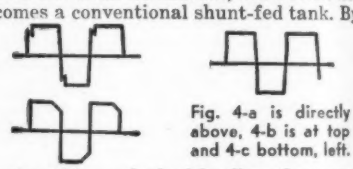

Fig. 4-a is directly above, 4-b is at top and 4-c bottom, left.

The tuning unit is a desirable feature when the set is to be used on widely separated frequencies. All of the frequency-determining elements of the set are mounted on a small chassis that has three 4-prong plugs mounted on its cover plate. These plugs are located so that they will match corresponding sockets mounted on the main chassis. Metal shield plates are fastened to the sides of the tuning unit to serve as guides when inserting the tuning unit into its sockets.

The crystals for the receiver are ground for frequencies 456 kc lower than the corresponding transmitting crystal. If it is desired to operate the transmitter on 3966 kc, for example, the receiver crystal will be ground for 3966 minus 456 or 3510 kc.

No troublesome microphone batteries are used because the battery voltage is obtained from a tap on the cathode resistor of the modulator.

The tubes selected for this rig proved to be unbeatable for operating in rough terrain under all conditions. The 6L6-G proved to be the outstanding tube as an r.f. power amplifier. On occasions 70 watts power input was used for c.w. operation and 50 watts phone without a blush from the plate.

## A METAL LENS

*(Continued from page 602)*

The necessary design theory was worked out in mathematical detail and systems of metal plates were subsequently built to duplicate the action not only of convex and concave lens but also of other optical devices, such as half and quarter wave plates and prisms.

The drawings compare an electronic lens with an optical one. Because the waves handled are an appreciable fraction of the diameter of the lens, some things can be done with them that cannot be paralleled with their glass counterparts. The concave lens elements, which consist of metal sheets, instead of becoming progressively wider toward the lens edges, as shown in the drawing, can be cut back every half-wavelength or multiple thereof, thus saving metal and making a lighter structure. The back of each metal plate thus resembles a huge saw, one side of each "tooth" following the lens curve, the other side straight and parallel with the lens axis.

## ELECTRONIC "NIGHT SIGHT"

*(Continued from page 603)*

plied by a storage battery, which, with the vibrator power pack which supplies high voltage for the image tube, is carried on the operator's back.

A soldier with a "sniperscope" (a "snooperscope" mounted on a carbine) was said to be more effective in stopping infiltration than 12 men with regular weapons. Here is how the infra-red carbine operates, as explained by an Electronic Laboratories official:

"A fighter armed with a sniperscope hears a sound. He points his weapon into the darkness, peers into the telescope, and turns on the power supply. He moves the weapon back and forth, like an invisible searchlight, his eye pressed to the telescope, until he sights the enemy, slowly crawling forward.

"The enemy soldier is unaware that he is impaled by a beam of invisible light of a greenish hue. (In the telescope all objects appear as various shades of green regardless of their color in daylight, due to the use of high-sensitivity green phosphor on the cathode-ray tube screen.) The U. S. soldier focuses his telescope quickly, lines up a bead on the enemy with the telescope sight, and, with a press of the trigger, there is one less infiltrating enemy."


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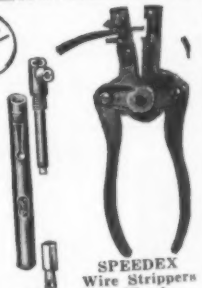

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## WHY THE TUBE SHORTAGE?

*(Continued from page 601)*

of three tubes required for set production, or nearly 35 million tubes per year.

It now appears that the radio industry is geared up to produce some 25 million radio sets per year, if and when the necessary materials become available. With FM and Television in the postwar picture, it looks as if the requirements for the original equipping of such sets will increase to approximately seven tubes per set as against the 5½ tubes per set in the prewar period.

From the calculations of these trends and other factors involved, it becomes evident that radio dealers and radio servicemen in the United States alone will probably absorb approximately 100 million tubes per year. *These requirements would be three times greater than those of the prewar period, making it necessary for the serviceman to turn away two out of three customers.*

The radio tube manufacturers feel that it is in the best interests of the industry to serve the set manufacturer first, because basically the radio receiver has made and will continue to make the tube market. Not even a radio serviceman without a single tube on his shelf would contradict the axiom: "no receivers, no tubes." Another important point: it is better at this state of our national economy to produce a number of tubes to go into a new receiver, rather than produce them to repair a worn-out antique which should be junked on account of old age. *Consumers want tubes; but new sets too.*

For these and other reasons tube manufacturers feel that new receivers should have first call on tubes; and accordingly they have allocated their production on the basis of *three tubes per new radio receiver and one tube for replacement.* Radio receiver manufacturers are and will continue to be the biggest customers for radio tubes. This is true in normal times and today too.

It is idle to pretend that all, or even the greater part of the approximately three million tubes a month allotted to repair and maintenance reach the serviceman, even were these quantities actually produced at present. RADIO-CRAFT is well aware that large numbers of these tubes "disappear" through intermediate commercial channels on their way from the factory to the ultimate consumer, the radio serviceman.

Throughout the whole industry, it is too well known that small radio set makers—the so-called "bed-room manufacturers" have no credit standing with the tube manufacturers, who therefore won't sell them. But the small set makers—there are hundreds of them—move heaven and earth to secure the precious tubes. They make "raids" on wholesalers, radio stores, department stores—yes they even buy tubes from the larger service establishments at fancy prices! This is a feature—albeit an unlovely one—of the present economic setup, and one that apparently can be relieved only by time and the natural play of economic forces. The radio serviceman is no worse off in this respect than retailers in other fields.

After weighing all the facts, RADIO-CRAFT estimates that the tube situation will probably continue unsettled for the rest of 1946. There may be quite a bit of improvement toward the end of the year, but the situation will not become entirely normal till sometime late in 1947. This analysis is based on the premise that there will be no unpredictable political or industrial crises or bottlenecks which would introduce totally new and upsetting factors.

Taking all the facts into consideration, the only conclusion that can be drawn is that it will be some little time before the situation will revert to a prewar normality, with sufficient tubes available to meet all demands.

## RADIO TERM ILLUSTRATED

*Suggested by: Quentin Piepergerdes, Kansas City, Mo.*

Wave Train

## HORN-IN-CONE SPEAKER

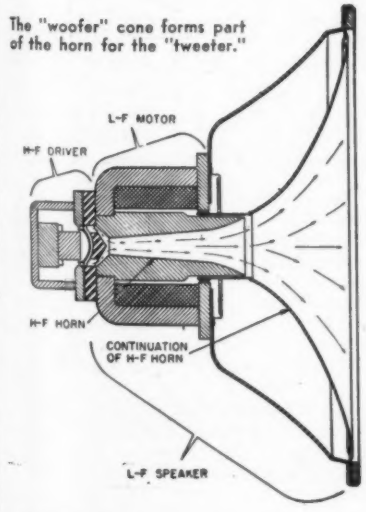
A loud speaker which is cone and horn in a single unit, has been developed by Jensen. The speaker is so constructed that the cone, which reproduces the low-frequency sounds, forms the horn of the high-frequency unit. Aptly named the Coaxial (Type H),

the new speaker is adapted to use in home radio receivers and phonographs, particularly for FM reception and high quality phonograph reproduction.

The Coaxial consists of two units, each reproducing a portion of the total frequency range. A compression-type high-frequency unit is attached to the back of a 15-inch direct-radiator low-frequency unit. The horn for the h-f unit is formed by a passage of expanding cross section through the core of the l-f unit, the carefully shaped diaphragm of the l-f unit forming a continuation of the h-f horn. The l-f diaphragm is driven by a conventional voice coil assembly.

The Coaxial speaker preserves the advantages of two-channel loud-speaker systems with "compression" or horn-type h-f units, while overcoming three major shortcomings of conventional two-way coaxial systems: (1) In the Coaxial, the mouth of the h-f horn is the full size of the l-f cone, thereby providing good acoustic loading in the vital cross-over frequency region. The horn mouth size is not compromised to reduce the obstacle the horn presents to radiation from the cone in the conventional horn-in-cone type.

(2) Since the cone of the l-f unit forms a smooth continuation of the h-f horn, there is no large multi-resonant cavity into which the h-f radiation can "spill over" nor into which the l-f unit can radiate. Objectionable resonances in the cross-over frequency region are therefore minimized.




(3) A special horn contour is used which gives much more uniform radiation over a broad angle than the conventional exponential type.

Electrical and mechanical cross-over networks are used which utilize the mechanical and acoustical properties of the two component channels in such a way as to yield optimum combined characteristics. Normally no control of the h-f response of the loud speaker other than that provided by the receiver tone controls, is necessary.

Additional h-f control may be provided by the use of an "L" pad. Alternatively, an "on-off" switch may be provided to cut out the h-f unit, although the resulting h-f response is not adequate for most purposes.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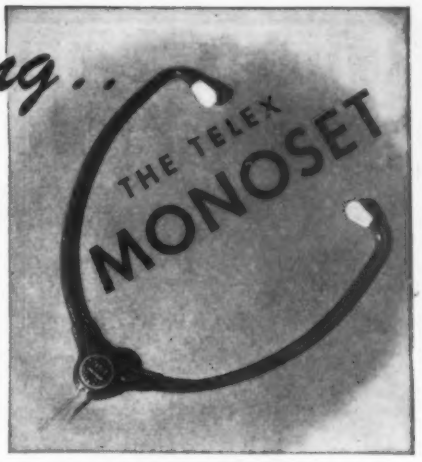


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## VIDEO AMPLIFICATION

*(Continued from page 614)*

Gain of a pentode video amplifier after proper compensation and where the plate resistance of the tube is large compared with the load resistance of the stage, is *the product of the load resistor* $R_L$ *and the tube's transconductance* $g_m$.

Overloading of a video amplifier must be avoided. When this happens and the next stage is an amplifier, the grid of the following tube draws current and charges the coupling condenser $C_o$. If the charge is large enough, it may be sufficient to cut off the following stage—thus blocking the video amplifier until $C_o$ becomes discharged. Since the value of $C_o$ is dictated by the method of low-frequency compensation *and cannot be made too small in value*, the only remedy for overloading is extreme care in operation.

### TYPICAL CIRCUITS

Complete circuit of a typical video amplifier is shown in Fig. 1. Upper frequency limit of this circuit is about 4 megacycles.

A pentode—type 6AC7—forms the nucleus. It is operated sufficiently above cut-off to avoid the difficulty of partial limiting in the presence of strong input signals.

The input signal is applied through any suitable coupling arrangement to the grid of the pentode. Screen voltage is supplied through resistor $R_s$, which acts both as a filter and a dropping resistor. Plate load of the tube consists of a relatively low value of resistance.

High-frequency compensation is provided by both a shunt peaking coil $L_a$ and a series peaking coil $L_b$. Low-frequency compensation is provided by the filter network consisting of resistor $R_x$, and condenser $C_x$.

The network $R_x$ $C_x$ also serves as a decoupling network to prevent variations in supply voltage from influencing the performance of the pentode. However, it is usual to supply both plate and screen voltages of a video amplifier with a *constant* source of power.

All large by-pass condensers—electrolytics—are paralleled by small paper condensers for more effective by-passing action over the entire frequency band.

The amplified video output is applied to the next stage or device through coupling condenser $C_o$.

Another typical video amplifier circuit—of slightly different arrangement—is shown in Fig. 10.

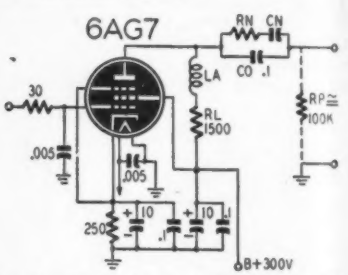


Fig. 10—Stage of a typical video amplifier.

The tube used is a type 6AG7 beam tetrode, operated in the conventional manner. Plate and screen voltages are supplied from a well-regulated source of power.

High-frequency compensation is provided by the shunt peaking coil $L_a$. Low-frequency compensation is provided by a filter network consisting of resistor $R_x$ and condenser $C_x$, acting to increase the gain of the stage below about 200 cycles. At higher frequencies, the output of the video stage is unaffected by this network. Resistor $R_x$ is non-inductive.


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Video amplifiers are widely used in television, since their wide frequency range makes them responsive to all picture signals.

Video amplifiers are used in the studio for amplification, polarity changing, and impedance matching—in order to preserve the wave form of the camera signals. They are used in the transmitter for amplification and modulation, and in the television receiver for polarity changing and amplification. Preserving the wave form of synchronizing pulses and blanking pulses are other duties performed by these amplifiers.

Radar employs video amplification in its pulse-forming circuits, much as such amplifiers are used in many industrial electronic devices. A frequency bandwidth of *at least* three megacycles is necessary in order that a square or rectangular wave or pulse be amplified with negligible distortion.

Video amplifiers are also used in the final stages of a radar pulse receiver. One or more stages follow the second detector to amplify the rectified signal sufficiently to give proper deflection when applied to the plates of a cathode ray tube.

Although capable of considerable power amplification, video amplifiers are invariably operated as voltage amplifiers—since the load is normally connected to a cathode follower stage, or to the deflection plates of a cathode ray tube.


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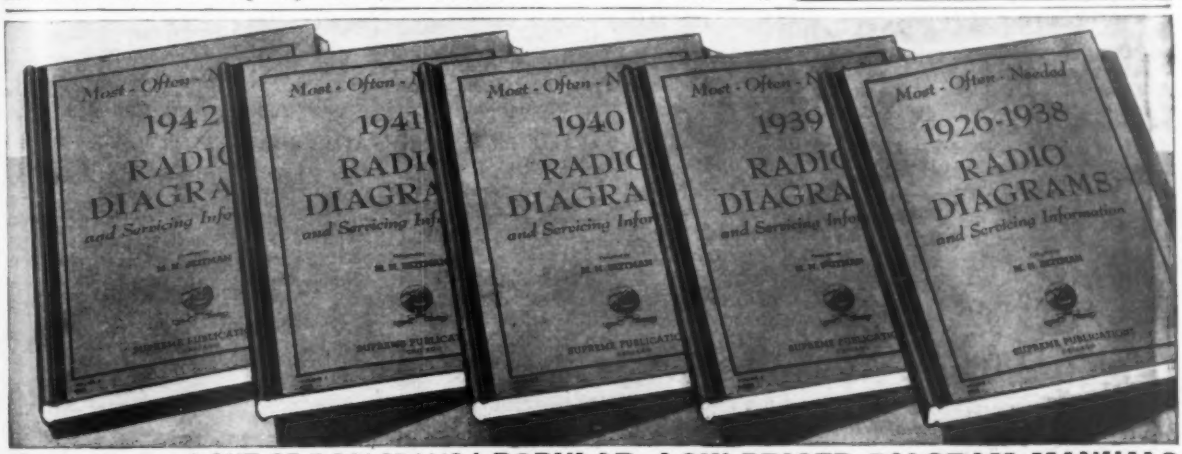


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# COMMUNICATIONS

## LETTER FROM A NETHERLANDS AMATEUR

*Dear Editor:*

This is a general call from the Dutch amateur station PA0CK, this time not by radio but in writing by letter with a kindly request, more a SOS than a request.

It is well known what has happened to us since 1940 in our small country with the German Army of occupation.

Many patriots lost their lives and a great part of the Dutch people their goods. In the Dutch Interior Forces (the Dutch "Maquis") I lost four friends by a raid of the German Police at our clandestine radio station (for contact with England). For a wonder I escaped and I am glad to live and to take care of my wife. The German S.S. made inquiries in our home but we had been warned and were not there. By our return all my electrical instruments, tools, photographic apparatus, wireless materials and tubes and—last not least—all our linen had disappeared.

And now our troubles. By May we are expecting our first baby and now we have too few baby articles to receive our little stranger properly. My request to one or more radio friends is as follows: to help us with the baby articles which we need, as wool, little clothes, napkins, etc., but with the condition that I send back specific Dutch articles (possibly requested) so soon as it is possible for me to express my thanks.

Soon I hope to make contact by radio with the W . . . . stations of the U. S. A. I am thanking you in anticipation for the trouble, help and this QSO and hope to receive QSL.

C. P. A. KANTERS, PA0CK,
*Dreibergenstraat, 4,*
*The Hague, Holland*

## WHERE IS ALL THAT YANKEE INGENUITY?

*Dear Editor:*

What I would like to see is more on how to use stuff out of the junk box. We overseas hear an awful lot about the great property of the Yanks to "make do" and improvise. Now let's see it in action! I would especially like to see articles on simple superhets and sets using one tube with multiple functions.

Some of us are still at school and haven't learned the mathematics you use in describing the technical points. I know it can't always be done, but couldn't you give us a few *simple* articles now and then? Give us the fundamentals of things like negative feedback circuits and inverters? I was only a babe when those circuits first came out.

Anyhow I still think RADIO-CRAFT is the best magazine I know.

G. RANDLER,
*Natal, S. A.*

## RETURNED SERVICEMEN'S LETTERS

*Dear Editor:*

The letter you printed from one of your readers on page 364 of the February issue makes me upset every time I think of it. This is putting it mild too. It seems to me he is working on the basis that the wheel that does the squeaking is the wheel that gets the grease. I think he is using the wrong type of squawk. He fought in the war, was disabled and is to be commended. I really would like to help the guy if I could. I didn't fight in the war, was on defense as an electrician for two years, but have been in radio since the time a Crosley Triadyne was de luxe equipment.

At times I feel the same way he does about the whole thing, but we can't control present conditions in five minutes. It may seem that the larger concerns are getting more than their share of supplies and attention, but in percentage we are getting as much, maybe more. I think everything will iron out all right, but it will probably take a considerable time.

By the way, Editor, you are to be commended for printing that letter. It shows that you are made out of the right kind of stuff.

CLAUDE M. PREW
*New London, N. H.*

## ERRORS IN SUPER-REFLEX RECEIVER

*Dear Editor:*

I regret to inform you that the schematic of the "Super-Reflex Radio" as published on page 403 of the March issue contains two serious errors:

The resistor R5 is connected to the primary L3. It should be connected to the grid return of the secondary of L3 instead. As shown the high voltage is in the a.v.c. circuit.

The lead from prong No. 4 of the 7E7 is shown connected to the grid return of L3. This shorts the audio signal to ground through C9. No connection should be made at this point.

I hope you can make an early issue with the necessary connections.

W. T. CONNATSER,
*San Francisco, Calif.*

*(Radio-Craft* regrets the error, which is due in large part to the new and unorthodox nature of Mr. Connatser's circuit, which permits one tube to do the work of three, but leaves checkers of schematics in some doubt as to whether connections are correct or not.—*Editor)*

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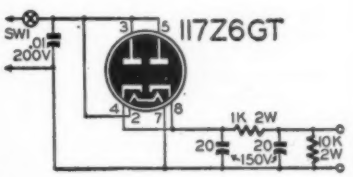
## A.C.-D.C. "B" BATTERY

THIS small power supply is not unusual as the simple diagram goes, but it was constructed like a 45-volt "B" battery, so as not to use up too much space in the battery compartment.

A 117Z6-GT duo-diode full-wave rectifier is expensive, but space was saved. The a.c. maximum plate voltage is 117 per plate and the tube has a heater current drain of .075 milliamperes with a d.c. output current of 60 ma per plate. The rectifier plates are connected in parallel, **resulting in 120 ma** maximum output and halfwave rectification.

The diagram of the portable "B" rectifier is shown in the figure. A single-pole single-throw thumb switch was placed in the line cord about two feet from the plug end so the rectifier could be turned off when not in operation. This switch can be omitted if the a.c. cord is pulled from the wall receptacle after the receiver has been switched off. The panel and switch on the battery receiver must still be used because the "A" battery will still be in circuit if the power supply's switch is "off."




A small mounting strip was fastened to the bottom panel with 8-32 bolts and accessories. The a.c. line cord ends were soldered directly to this. Besides the mounting strip we placed a .01 μf paper condenser to filter out all noise from electrical appliances on the power line. One side of the a.c. cord was *not* grounded through a condenser as usual to the metal chassis; no electrical connections were soldered to this metal case because a shock could be had from it to the ground.

The wafer octal tube socket is placed upside down and spaced from the chassis with two ½-inch fiber spacers. This made more space available for other components and lessened danger of shorting to metal chassis.

A 1000-ohm 2-watt carbon resistor in conjunction with a dual 20-μf electrolytic condenser was used for filtering. This condenser must be placed as far as possible from the 117Z6-GT tube to avoid drying out the electrolytic solution. We figured, with about 117 volts output at the terminals of the cathode, the 1000-ohm carbon resistor would produce a voltage drop of 16 volts with 16 ma of current flowing through it. This current drain of 16 ma was the estimated drain of the battery receiver. This now leaves 101 volts on the output terminals of the power supply. To

*(Continued on following page)*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## A.C.-D.C. "B" BATTERY

*(Continued from page 657)*

insure greater stability, a 10,000-ohm 2-watt bleeder was placed in the circuit from B-plus to ground, giving a 10-ma bleeder current and dropping the output voltage to 91 volts. Also this bleeder current flows through the 1000-ohm resistor at 10 ma, producing a 1-volt drop. Voltage output is now 90, with receivers drawing 16 ma of current. Most 6-tube battery receivers draw about this much. The miniature tube variety draws around eight or nine ma. The filament supply was omitted because the cathodes of the 117Z6 will not safely pass the additional current. The battery male plugs could still be used if one plug was shorted out with a piece of wire. Tape up the remaining male plug.

The chassis was constructed from galvanized sheet metal of 3/32 material 3⅝ inches wide, 4½ inches long and 2¼ inches deep. ⅛-inch holes were drilled and placed along the bottom and sides for tube ventilation. A female socket was torn from one of the old "B" batteries and placed in the top of the chassis.


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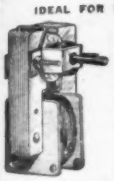

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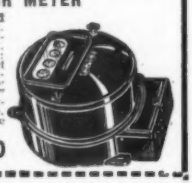

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# BOOK REVIEWS

**TELEVISION SIMPLIFIED, by Milton S. Kiver. Published by D. Van Nostrand Co., Inc. Stiff cloth covers, 5½x8½ inches, 375 pages. Price $4.75.**

Few practical books on this subject have been written for the serviceman or technician lacking knowledge of engineering mathematics, and equally lacking in patience to follow dissertations on the historical or economic aspects of the art to get a little information as to the how and why of television.

The author of this work plunges immediately into detail after a single introductory chapter which describes the general features of television receivers and transmitters, scanning, camera tubes, the need for wide transmission bands and other points necessary to present a broad general idea of the subject.

The second chapter discusses u.h.f. waves and suitable television antennas. From here the author goes into r.f. and i.f. circuits, detectors, a.g.c. circuits, video amplifiers, d.c. reinsertion, cathode-ray tubes, synchronizing and deflecting circuits.

Having covered the circuit details, the author proceeds to deal with typical television receivers and their adjustment. A long chapter (36 pages) is devoted to servicing television sets. Some space is given to special circuits, color television and the frequency modulation used for the audio transmissions associated with television programs. A glossary of television terms and a brief index complete the book.

**INSIDE THE VACUUM TUBE, by John F. Rider. Published by John F. Rider, Inc. Stiff cloth covers, 5½x8½ inches, 407 pages plus preface and table of contents. Price $4.50.**

For the first time in a book intended for the student or beginner, a modern approach is made to the theory and operation of electron tubes. After a brief introduction to electrons and thermionic emission, vacuum-tube action is considered on a basis of fields and charges. The result is a clearer and by no means less simple explanation of the tube and its workings than has hitherto appeared.

Though the attack is from the same point as an advanced text, the manner of presentation is kept to the beginner's level, and the material is lightened by illustrative cartoons which fully explain electronic laws and tube operation. Another interesting departure in illustration is the three-dimensional drawings, which when viewed through the red-blue spectacles provided with the book permit the reader to visualize actions which cannot be presented properly in a flat two-dimensional picture.

After describing why and how the tube functions, its characteristics as a part of electronic apparatus are considered, and a number of chapters are given to dynamic curves, transfer characteristics, voltage and power ampli-

*(Continued on following page)*

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## BOOK REVIEWS

(*Continued from page 659*)

fiers, and even the cathode follower. Miscellaneous tubes, including cathode-ray and photoelectric types, are described in the last chapter.

The book lacks an index, but this omission is balanced by complete subheading in the table of contents.

## WORLD-WIDE STATION LIST

(*Continued from page 622*)

| Freq. | Station | Location and Schedule |
|---|---|---|
| 17.700 | GVP | LONDON, ENGLAND; Netherland Indies, 6 to 6:15 am; 7 to 7:15 am; Chinese beam, 5:30 to 6 am; African beam, 6:30 to 6:45 am. |
| 17.715 | GRA | LONDON, ENGLAND. |
| 17.730 | GVQ | LONDON, ENGLAND; Near East beam, 6:30 to 10:15 am; Central and South American beam, 6 to 10:15 am; 11:45 am to 4 pm; Indian beam, 1:30 to 4 am. |
| 17.750 | WRUW | BOSTON, MASS.; Central American beam, 6:30 to 8:15 pm; European beam, 9 am to 12:45 pm. |
| 17.760 | KWID | SAN FRANCISCO, CALIF.; South American beam, 5 to 7:30 pm. |
| 17.765 | | PARIS, FRANCE; 6 to 8 am. |
| 17.770 | OTC | LEOPOLDVILLE, BELGIAN CONGO; 6 to 9:30 am; 11:30 am to 12:15 pm. |
| 17.780 | WNBI | NEW YORK CITY; South American beam, 5 to 6:15 pm; European beam, 7:30 am to 1 pm. |
| 17.780 | KNBA | SAN FRANCISCO, CALIF.; South Pacific beam, 2 to 4:45 pm. |
| 17.790 | GSG | LONDON, ENGLAND; African beam, 11 am to 2:15 pm. |
| 17.800 | WLWO | CINCINNATI, OHIO; South American beam, 5 to 5:45 pm; European beam, 7:30 am to 2:30 pm. |
| 17.800 | KRHO | HONOLULU, HAWAII; Philippine beam, 4 to 11:30 am. |
| 17.800 | OIX5 | LAHTI, FINLAND; 8 am to 12:30 pm. |
| 17.810 | GSV | LONDON, ENGLAND; African beam, 4 to 10:15 am; Indian beam, 4 to 10:15 am. |
| 17.820 | CKNC | MONTREAL, CANADA; European beam, 7 am to 2 pm. |
| 17.830 | WCBN | NEW YORK CITY; European beam, 6 am to 12:45 pm. |
| 17.830 | VUD10 | DELHI, INDIA; 5 to 7 am. |
| 17.845 | | BRUSSELS, BELGIUM; 6 to 7 am; 11 am to noon. |
| 17.850 | KCBF | LOS ANGELES, CALIF.; South American beam, 5 to 10:45 pm. |
| 17.870 | GRP | LONDON, ENGLAND; African beam, 10:30 am to 12 pm. |
| 17.955 | WLWLI | CINCINNATI, OHIO; European beam, 8 am to 12:45 pm. |
| 18.025 | GRQ | LONDON, ENGLAND. |
| 18.080 | GVO | LONDON, ENGLAND; South American beam, 6 to 10:15 am; 11:45 am to 12:45 pm. |
| 18.135 | PMC | BATAVIA, NETHERLAND INDIES; 11:30 pm to 9:30 am. |
| 18.160 | WNRA | NEW YORK CITY; European beam, 6 am to 1:30 pm. |
| 21.470 | GSH | LONDON, ENGLAND; African beam, 9:15 to 10:45 am. |
| 21.530 | GSJ | LONDON, ENGLAND; Indian beam, 4 to 8:45 am. |
| 21.550 | GST | LONDON, ENGLAND. |
| 21.640 | GRZ | LONDON, ENGLAND. |
| 21.675 | GVR | LONDON, ENGLAND; 6 to 8:30 am. |
| 21.710 | GVS | LONDON, ENGLAND. |
| 21.750 | GVT | LONDON, ENGLAND. |
| 25.750 | GSQ | LONDON, ENGLAND. |
| 26.100 | GSK | LONDON, ENGLAND; Central and South African beam, 6:15 to 8:45 am. |
| 26.400 | GSR | LONDON, ENGLAND. |
| 26.550 | GSS | LONDON, ENGLAND. |

## BETTER BROADCAST TUNER

(*Continued from page 636*)

Parts List

RESISTORS

R1—10,000 ohms potentiometer
R2, R3—100,000 ohms
R4—400 ohms
R5—10,000 ohms
R6—50,000 ohms
R7—60,000 ohms
R8—400 ohms
R9—10,000 ohms
R10—60,000 ohms
R11—5,000 ohms, 10 watts (optional if power supply is well filtered)

CONDENSERS

C1, C2, C3—gang condenser, .00036
C4, C5, C6, C7, C8, C9—.1 μf
C10—8 μf, 450 volt electrolytic
C11—.0001 μf mica
C12—.1 μf, 600 volt, tubular

MISCELLANEOUS

L1—14-7413 Meissner Iron Core shielded coils
L2—14-7558 Meissner Iron Core shielded coils
L3—14-7558 Meissner Iron Core shielded coils

## Radio Thirty-Five Years Ago

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| | |
|---|---|
| Modern Electrics | 1908 |
| Electrical Experimenter | 1913 |
| Radio News | 1919 |
| Science & Invention | 1920 |
| Radio-Craft | 1929 |
| Short-Wave Craft | 1930 |
| Wireless Association of America | 1908 |

Some of the larger libraries in the country still have copies of Modern Electrics on file for interested readers.

High Frequency Currents, by *Norman Barden.*

The Rosing Telephot.

Gaumont (Talking Machine) Apparatus.

New Bellini-Tosi Apparatus, by *A. C. Marlowe.*

Wireless Interference and Perturbations, by *J. E. Taylor.*

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Simple Electrolytic Interrupter, by *Alfred Bretonnel.*

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Sending Condenser for One-Inch Coil, by *J. McClain.*

Simple Sending Condenser, by *N. C. Goin.*

An Adjustable Condenser, by *W. Schurmann.*

Break-In Key, by *C. W. Carlstrom.*

A New Ball-Bearing Slider, by *O. J. Hurlbut.*

Pocket Radio Receiver, by *L. O. Mumford.*

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HUGO GERNSBACK, *Editor*

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SEE PAGE 680

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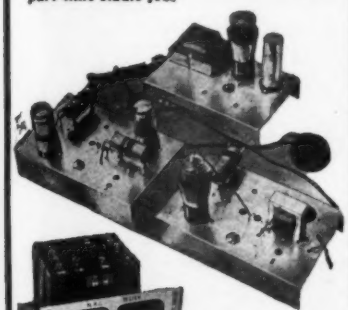

You build MEASURING INSTRUMENT above early in Course, useful for Radio work to pick up EXTRA spare time money. It is a vacuum tube multimeter, measures A.C., D.C., R.F. volts, D.C. currents, resistance, receiver output.

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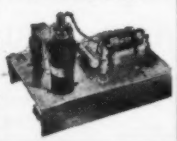

The men at the right are just a few of many I have trained, at home in their spare time, to be Radio Technicians. They are now operating their own successful spare time or full time Radio businesses. Hundreds of other men I trained hold good jobs in practically every branch of Radio. Doesn't this PROVE my "50-50 method" of home training can give you BOTH a thorough knowledge of Radio principles and the PRACTICAL experience you need to help you make more money in the fast-growing Radio industry?

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***Simple to operate . . . because signal intensity readings are indicated directly on the meter!***

Essentially "Signal Tracing" means following the signal in a radio receiver and using the signal itself as a basis of measurement and as a means of locating the cause of trouble. In the CA-11 the Detector Probe is used to follow the signal from the antenna to the speaker — with relative signal intensity readings available on the scale of the meter which is calibrated to permit constant comparison of signal intensity as the probe is moved to follow the signal through the various stages.

*Features:*

- ★ **SIMPLE TO OPERATE — only 1 connecting cable — NO TUNING CONTROLS.**
- ★ **HIGHLY SENSITIVE — uses an improved Vacuum Tube Voltmeter circuit.**
- ★ **Tube and resistor-capacity network are built into the Detector Probe.**
- ★ **COMPLETELY PORTABLE — weighs 5 lbs. and measures 5" x 6" x 7".**
- ★ **Comparative Signal Intensity readings are indicated directly on the meter as the Detector Probe is moved to follow the Signal from Antenna to Speaker.**
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The model 450 comes complete with all operating instructions.
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- **Tests by the well-established emission method for tube quality, directly read on the scale of the meter.**
- **Tests shorts and leakages up to 3 Megohms in all tubes.**
- **Tests individual sections such as diodes, triodes, pentodes, etc., in multi-purpose tubes.**
- **New type line voltage adjuster.**
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- **Works on 90 to 125 Volts 60 Cycles A.C.**

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# ELECTRONIC MULTI-METER

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BY THE EDITOR

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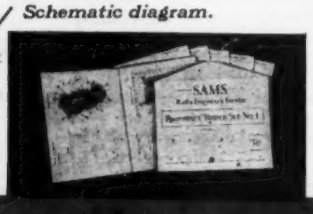


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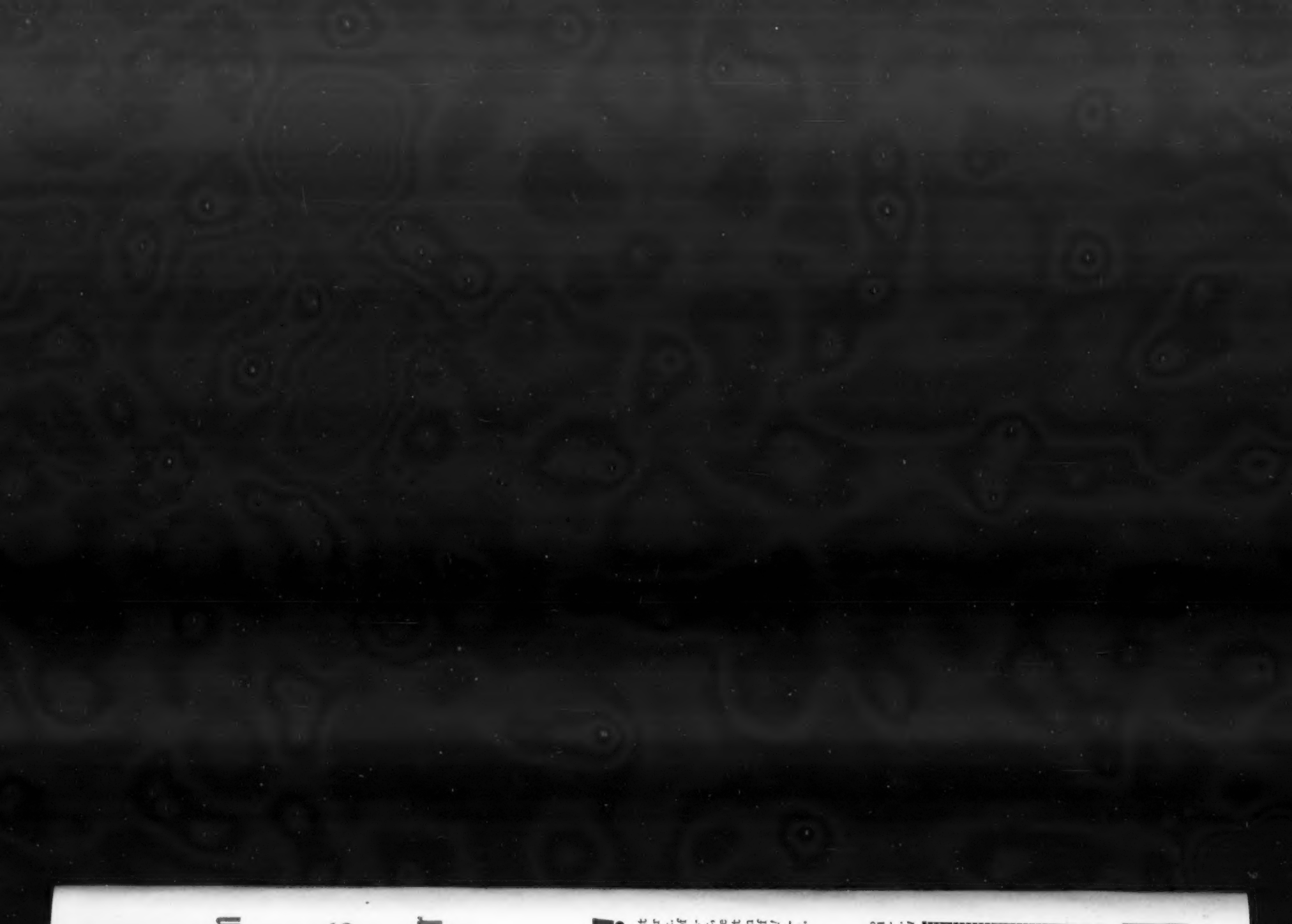

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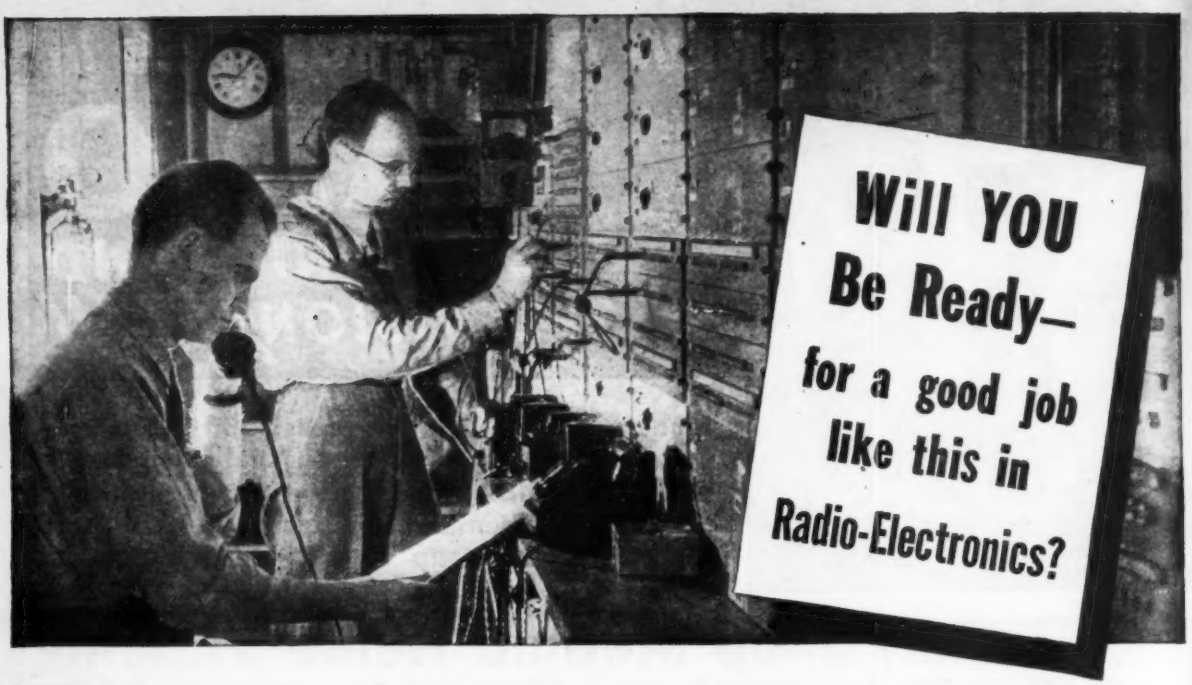


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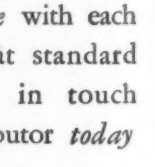

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By HUGO GERNSBACK

# SECRET COMMUNICATION

***There are many media suitable for communications***

THE art of secret, or private communication is as ancient as the human race. Ever since the dawn of civilization men have tried to perfect ways and means of communicating with each other privately or secretly—be it during peace time or in war. During the past 100 years science has enabled the communications field to expand enormously, and new means of communication have been invented in profusion.

The advent of electricity, and particularly the telegraph and telephone, have made strictly private and often secret communication easier. Thus, during war, even in the earlier days of the telephone and telegraph, special means were developed to make communication over these media as secret as possible in order that an enemy could not decipher the message. Special machines for coding purposes were invented, but few have proven to be "unbreakable."

Later on, when radio expanded, new means were found for private communication, but here also secrecy was only partial.

During peace time, for instance, when you telephone an overseas friend by the present radio transmission system, the ordinary person who has a short wave radio set cannot listen in on your conversation because the talk is split over two separate channels. Unless the listener has the combination and the special radio hookup to combine the two messages into one, he hears only gibberish, which he cannot make out. This gives partial secrecy. Yet a radio engineer might hook up a special radio receiver to listen into anyone's Trans-Atlantic or overseas communication should he so choose. The secrecy, therefore, is not complete.

There are, of course, code machines and other means by which the secrecy can be almost perfect, but during the war it was found that *no* system could remain secret for long. *All* codes were eventually "broken."

This spurred on the technicians of all the warring nations as well as others to find some media which would be more secret than wire or radio.

The Germans possibly were the first to grab the ancient Alexander Graham Bell Photophone whereby one talks over a light ray without any intervening wires. The Bell Photophone was invented in 1880, and has often proven not only an interesting stunt for experimenters to converse with each other over a light ray for miles, but had also a number of commercial applications in the past. When radio amplifiers came into vogue the instrument could be perfected and made more sensitive by modern instrumentalities. Soon the Germans were using it in their so-called "Lichtsprecher" (lightspeaker) during World War II. This is merely a refinement of the Bell Photophone.

With this instrument troops and command posts could talk over a light ray for many miles. The secrecy here was nearly perfect. Such a conversation could not be "tapped" easily between two points as long as the listener was not in a direct line between the points between which communication was carried on. Between two points, inaccessible to the enemy, it is therefore, possible to converse without much danger. It is possible to use ordinary sunlight as well as any other strong light source. The light beam is then modulated and communication established.

There are many other ways to communicate in a similar manner without using visible light rays. The Germans also early perfected a system whereby infra-red waves were used and this system also was fairly secure, particularly during night-time.

When one speaks over a visible light beam at night the position is apt to be given away to the enemy, and if he is within gun range he will try to destroy the source of the light, because he knows it is being used for communication. Not so with infra-red waves which are difficult to spot and difficult to locate, and, therefore, relatively safe.

So far, however, infra-red communication has not been satisfactory over greater distances than about ten miles. It is certain, however, that it will be improved in time; only the horizon will then limit the range of communication.

There are yet other means at our disposal as, for instance, ultra-violet ray communication. Very little about this has appeared in print and there are certain difficulties connected with it, but in due time ultra-violet radiation will also be used for secret communication.

Science does not stop here. We give a few more examples, which so far have not been described—to the best of our knowledge—

Human ears can only hear up to a certain point of the sound scale, thus any vibration beyond 15,000 cycles becomes inaudible to us. That is, for human beings, not for animals.

Thus dogs and particularly canary birds, can hear much further up in the sound spectrum than human beings. There is now manufactured a special dog whistle, which only dogs can hear. You blow it, but hear nothing whatsoever as the sound waves generated by this whistle are beyond human reach. The dog, however, hears it very well over quite a distance.

Scientists a few years *(Continued on page 718)*

# RADIO-ELECTRONICS

## Items Interesting

**AUTO TELEPHONE** was made available last month to operators of motor vehicles in St. Louis, Missouri. Officials of the Bell Telephone System, which introduced the service, state that it is being provided on an experimental basis but under regular commercial conditions.

Three classes of service will be offered: a general two-way telephone service between any vehicle and any regular telephone or other mobile unit; a two-way dispatch service between a customer's office and his own mobile units only; and a one-way signaling service to mobile units.

The rates for a three-minute general service message within the area served by the St. Louis radiotelephone station range from 30 to 40 cents depending on the location of the land telephone. The charge for a one minute two-way dispatch call is 15 cents. The rates for most calls will not vary with the location of the vehicle. If the calling or called land telephone is outside the St. Louis service area, toll rates apply.

The radio equipment on the vehicle may be provided either by the customer or the telephone company. If furnished by the company, the monthly service charge is $15 plus an installation charge of $25.

The transmitting and receiving units, having a power of about 20 watts, will be located in the trunk of a car or in any suitable place on a truck. Each of the two units will be contained in a steel case approximately 10 inches wide, 18 inches long and 8 inches deep, and will weigh about 40 pounds. The single antenna for both sending and receiving will be approximately 18 inches in length, mounted on top of the vehicle.

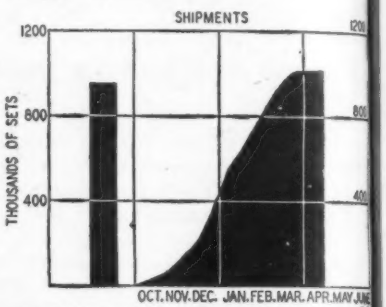
The radiotelephone central office equipment employed in St. Louis includes a transmitting station and five receiving stations. The antenna of the 250-watt transmitter is located on a 50-foot mast atop the Southwestern Bell headquarters building. The receiving stations are located in various sections of the city so that vehicles' relatively low-powered radio sets will be within range at all times. The receiver nearest a calling mobile unit will pick up the voice signals and send them on their way by telephone wire. Radio channels within the range of 152-162 megacycles have been assigned for the service.

**THE RADIO PARTS SHOW,** first since 1944, was held at the Stevens Hotel in Chicago May 13 to 16. It attracted a record attendance of 7,562 exhibitors and spectators, according to a report issued last month. This was considerably more than anticipated and is indicative of the widespread trade interest in new lines of radio merchandise. Attendance at the show was limited to manufacturers, distributors, manufacturers' representatives, publishers and a small number of guests.

Among the many products shown by radio and radio parts manufacturers, FM and television antennas were particularly noticeable. A number of entirely new products were exhibited, the most striking being a ceramic that acts as a modulated light source for a light beam telephone. As it was primarily a parts show, there were few exhibits of complete radio sets, though test instruments were well represented.

This mobile installation extends the communication facilities of the office to the car.

**RECEIVER PRODUCTION** has levelled off at about a million sets monthly, according to a last month's report from the Civilian Production Administration. This amounts to approximately 90 percent of prewar production.




Graph shows radio shipments to April, 1946.

Construction of radios, which started from scratch last October, reached a rate of 500,000 sets monthly in the middle of January and one million in early March. The rate then remained constant for the rest of the month and through the whole month of April.

The figures are based on *shipments* of radios, and therefore may not exactly mirror production in all cases.

**VETERANS** who go into business prefer to set up radio service shops and stores or electrical appliance establishments, it was revealed last month by the Office of Small Business.

Inquiries to the office during the past year showed that nearly three times as many veterans wished to start business in these lines as in the next popular classification, apparel stores. Almost as popular as the apparel store are filling stations, grocery stores and restaurants, all of which elicted a little more than a third as many inquiries as the electrical-appliance-radio-store group.

**RADIO TUBE PRICES** were increased from 15 to 20 percent as of May 1st, it was announced by the OPA. The 20 percent manufacturers' ceiling price increase was given for replacement tubes, others being raised 15.5 percent. Cost to the consumer would not be affected, OPA said.

**SYNCHROTRON,** a new atom smasher, may split not only atoms, but the protons and neutrons themselves.

Discovered independently by Prof. Edwin M. McMillan, co-discoverer of neptunium, and the Russian scientist, V. Veksler, the new instrument will combine features of the betatron and cyclotron. It is expected to accelerate electrons to a potential of 300 million electron volts.

# MONTHLY REVIEW

## *to the Technician*

**WARNING** that Army surplus walkie-talkies and other radio transmitting equipment now being offered for sale *must not* be used by unlicensed persons was issued last month by the Federal Communications Commission. In many cases where equipment is offered to the general public, some people believe the sale implies a right to use the equipment. This is by no means the case, the FCC points out, and unauthorized use of such transmitters by the general public is illegal and subject to $10,000 fine, or imprisonment, or both.

The Commission also pointed out that none of the equipment at present on sale is designed to operate in the 460-470 megacycle band allocated to the proposed Citizens' Radio Service.

**SPORT BROADCASTING** reached a new high in realism last month. The microphone was moved from its accustomed place at the ringside and actually inserted between the body of one of the boxers and the glove of the other. On-the-spot broadcasting!

Actually the mike was attached inside a catcher's mask worn by Stan Lomax, WOR's veteran sportscaster, in a sparring bout with Joe Louis, at his training camp in New Jersey.

Stan Lomax wished to tell his audience "how it feels to be in the ring facing the Champion," and hit on this as the best way. Translated into sound via the mike, light taps on the mask "felt" like blows from a battering-ram. The tough sports commentator managed to stay in the ring for one round, terminated by the referee when the mike broke loose from its fastenings.

A new era of sports broadcasting appears to have been opened, and we can look confidently forward to a televised scene of a fight in which both the contestants wear u.h.f. pack sets. The radio owner will then both see and hear the blows, and sportscasters will be unnecessary.

Joe Louis and Stan Lomax meet in the ring.

**AMATEURS** now have available a large number of bands. As of June 1st, all restrictions had been lifted from the old 80-meter band, giving the ham the operating frequencies of 3.5 to 4 mc that he enjoyed before the war.

The following frequencies and types of emission are now authorized:

| | | | |
|---|---|---|---|
| 27.185 | to | 27.455 mc | A0-A1-A2-A3-A4-FM |
| 28.0 | to | 29.7 | A1 |
| 28.1 | to | 29.7 | A3 |
| 29.0 | to | 29.7 | FM |
| 50.0 | to | 54.0 | A1-A2-A3-A4 |
| 52.5 | to | 54.0 | FM |
| 144.0 | to | 148.0 | A1-A2-A3-A4-FM |
| 235.0 | to | 240.0 | A1-A2-A3-A4-FM |

420.0 to 430.0, 1215 to 1295 mc, 2300 to 2450 mc, 5250 to 5650 mc, 10,000 to 10,500 mc, and 21,000 to 22,000 mc bands are available for A1, A2, A3, A4, A5 and FM transmissions. The peak antenna power on the 420 to 430 mc band shall not exceed 50 watts. The portion of the 144 to 148 mc band lying between 146.5 and 148.0 mc shall not be used by any amateur station located within 50 miles of Washington, D. C., Seattle, Wash., or Honolulu, T. H.

Licensed operators are permitted to operate on any frequency above 30,000 megacycles using any type of emission.

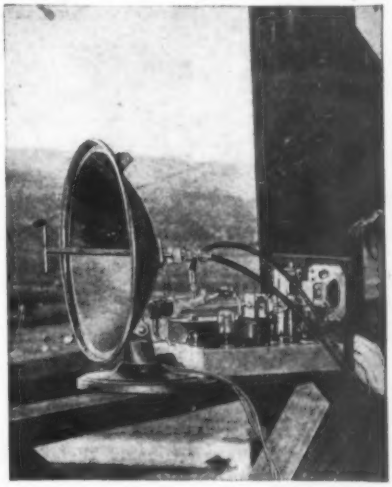
**SELECTIVE ABSORPTION** of very short radio waves may limit propagation at super-high frequencies, reported the recent Cambridge meeting of the American Physical Society.

Water vapor molecules absorb a wavelength of one and a quarter centimeters, while the oxygen molecules absorb a wavelength of half a centimeter.

**FIRST AMATEUR CONTACT** on the 2300-2450 megacycle band was claimed last month by two General Electric engineers, George H. Floyd, W6OJK/2, and Arthur R. Koch, W9WHM/2. The contact was between two buildings in the Schenectady G.E. works, and was on phone.

The ultra-high-frequency apparatus used disc-seal 2C40 "lighthouse" tubes and parabolic reflectors. One at least of the stations was a transceiver.

This is not the first amateur communication on the ultra-highs, as operation was carried on in the 5250-5650-megacycle band some months ago. (RADIO-CRAFT, May, 1946). It does mark the opening of a new ham-band.



Above—One of the two 2300-2450 mc stations.

Below—The two constructors adjust their apparatus. Wire-mesh parabolic reflector ahead.

# HOW MINE DETECTORS WORK

By ERIC LESLIE

## *Secret Wartime Device Now Described*

METAL finders or treasure locators have long intrigued the adventurous experimenter's imagination. With the coming of war, the metal locator came of age. Called a *mine detector*, it was produced in the hundreds of thousands and used all over the world. Much interest was aroused in the instrument, but military secrecy covered all details of its effectiveness, operation or even theory.

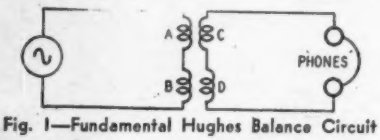


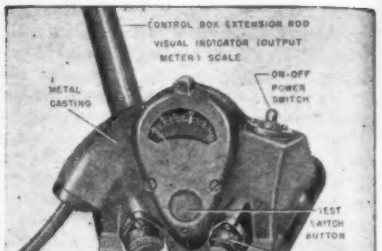

Fig. 1—Fundamental Hughes Balance Circuit

The principles underlying metal detectors were well known long before the war. Most of them work on the balanced field principle, used to detect the presence of metals at least 60 years ago (Hughes Balance Metal Detectors, RADIO-CRAFT, January, 1944). The detector widely used for locating metallic mines resembled the original Hughes Balance very closely, even using a relatively low audio frequency instead of the r.f. waves used by most of the later treasure locators.

The Hughes Balance, in its original form, consists of four coils. Two of these are connected in series with a source of alternating current. The others, coupled to the first two, are connected in series-opposing, so that the signal induced by A in C (Fig. 1) is cancelled out by the signal induced in D by B. If coupling between the two coils is perfectly balanced, there is no signal in the phones.

Variations in the circuit are employed in practical mine detectors and metal locators. One used in standard Army equipment consisted of three coils, two of which were connected to the transmitter and one to the receiver. The two transmitter coils were so connected and coupled that no signal was introduced into the field of the third or receiver coil. Another system, much used in radio-frequency metal locators, employs one transmitter and one receiver coil, so positioned that coupling between them is zero. Equipment using a large vertical transmitting loop and a horizontal receiving loop belong to this class.

These various balanced circuits have one feature in common—if any conducting material is introduced into the field surrounding the loops *the shape of the field will be altered*, and with it the coupling. Thus zero coupling will no longer exist, and a signal will be heard in the output.




Control head, showing the visual indicator.

A disadvantage of the two-loop system has been that—to get zero coupling—the two loops have been widely spaced. A common type consisted of a frame carried by the operator, on which the transmitting loop was mounted two or more feet behind his back, and the receiving loop two or three feet ahead of him. The rear vertical loop measured about two feet across and was carried approximately four feet above the ground, while the receiving loop—roughly the same size—was carried horizontally as near the ground as expedient. Such a bulky device would hardly do for military use.

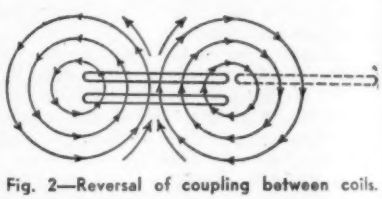
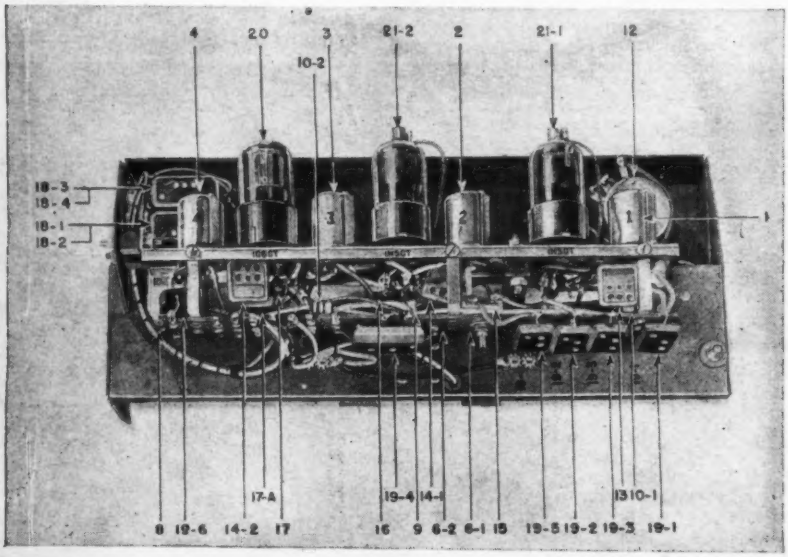


Fig. 2—Reversal of coupling between coils.

To bring this device into usable form, the problem of zero coupling was attacked in a new, ingenious manner. If two flat coils are placed so that the receiving is directly above the transmitting coil, they are coupled as shown at the left side of Fig. 2. If the receiving coil is removed and laid down beside the transmitting coil, they will still be coupled, but in the opposite direction. (Note arrows showing direction of force field.) Obviously if the one coil is slowly slid sidewise from the first position, coupling will decrease to zero at some point, then reverse in direction as the two coils are further separated. The mine detector *search head* is based on this principle. The coils in the search head are so positioned (Fig. 3) that




The improved American mine detector with 1G6, showing positions of all components.

No. Description of part.
1—Input transformer, search coil to grid. Pri to sec ratio 1:80, pri inductance .035 H.
2—Plate choke, 50 H at 1 ma d.c.
3—Output transformer, pri to sec ratio 10:1, pri inductance 35 H.
4—Osc transformer, plate to sec ratio 24:1, grid to sec ratio 12:1.
6—10,000 ohm resistor.
8—8,300 ohm resistor.
9—4.7 meg resistor.
10—1 meg resistor.
12—750-ohm wire-wound potentiometer.
13—.001 μf mica condenser.
14—.05 μf mica condenser.
15—.0002 μf mica variable condenser.
16—.01 μf molded paper condenser.
17—.02 μf mica condenser, 17-a .002 mica.
18—1 μf oil filled paper condenser.
19-1—.02 μf paper condenser.
19-2, 19-3, 19-5—.05 μf paper condenser.
19-4—.25 μf paper condenser.
20—1G6-GT tube.
21-1, 21-2—1N5-GT.

coupling is zero until the field around them is distorted by introduction of a mass of metal. Then some coupling takes place and a signal is heard in the phones.

The coils shown in Fig. 3 are each wound with 800 turns of No. 29 or 30 single silk enamel covered wire. Positioning for zero coupling is found by actual experiment and the coils then sealed into place with wax.

## THE CONTROL BOX

Any variations due to change in physical characteristics because of age, rough handling, or which may be introduced by electrical changes in the circuits to which they are connected, are compensated for by a pair of potentiometers, one of which balances out any stray capacity, the other coupling of a resistive nature between the two coils. These are shown in the dashed square marked "Control Head" in Fig. 4. The figure diagrams the simplest type of mine detector, which originated in England early in the war, and was afterward made in large quantities on both sides of the ocean. The potentiometers are both across the receiver coil, with a resistor or condenser in the movable arm connected to one side of the transmitter coil.

The control box is mounted on the handle of the instrument. In late models, this box also contains a meter for visual indications. A cable from it runs to the amplifier-oscillator unit, which was usually contained in a bag slung over the operator's shoulder. In the type shown in Fig. 4, this unit contains three tubes of the 1N5 or a similar type. One of these acts as a 1,000-cycle oscillator,

*(Continued on page 721)*

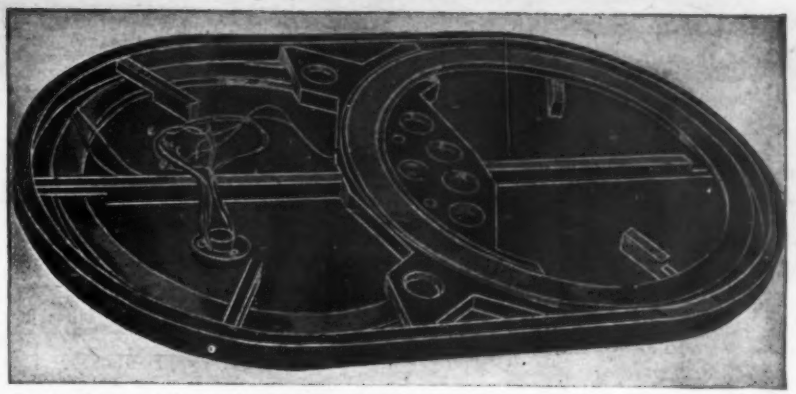


Fig. 3—The search head, showing how top coil is displaced to a position of zero coupling.

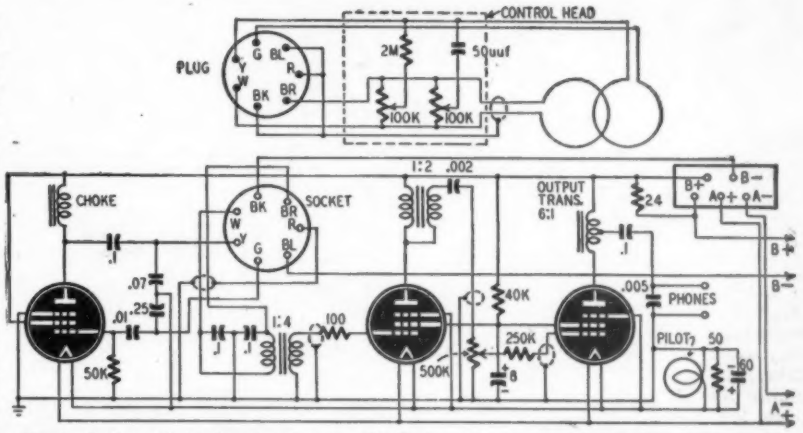



Fig. 4—Earlier and simpler mine detector. Oscillating and receiving circuit elements are tuned to 1000 cycles. "Off-On" switch is in battery unit (coded plug, at center right).

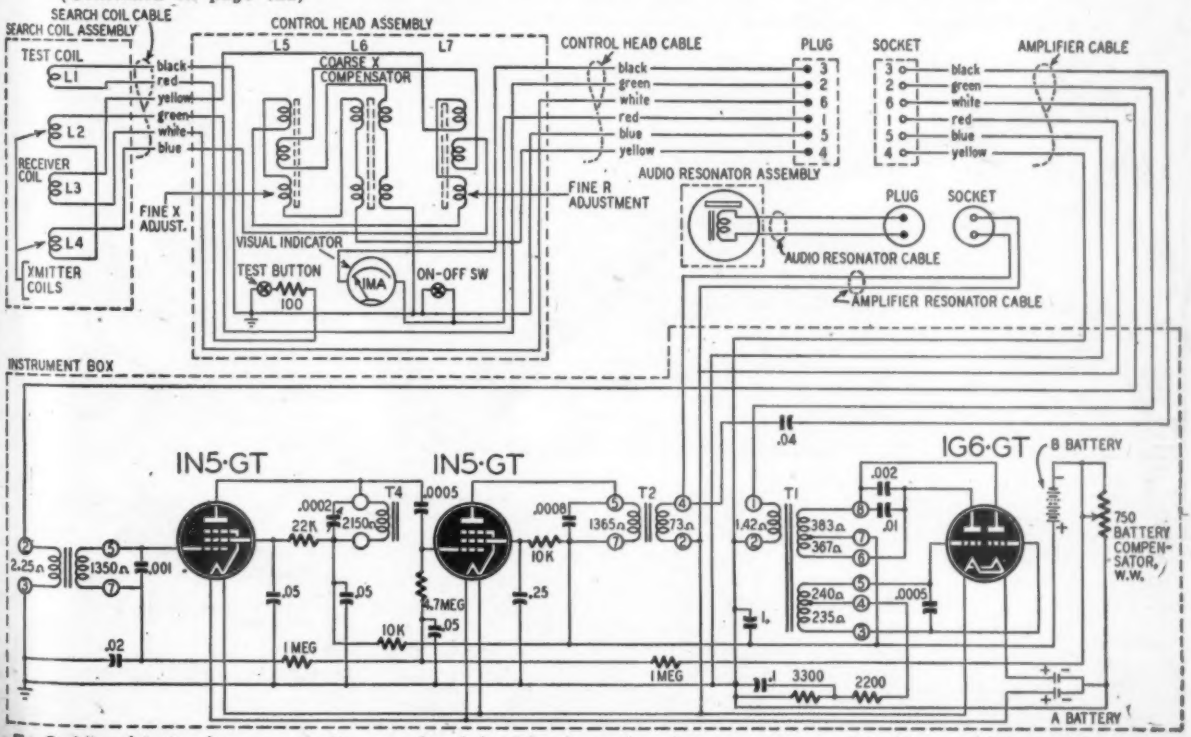



Fig. 5—Mine detector shown on opposite page. Search head has four coils, and compensators are adjusted by movable iron and brass cores.

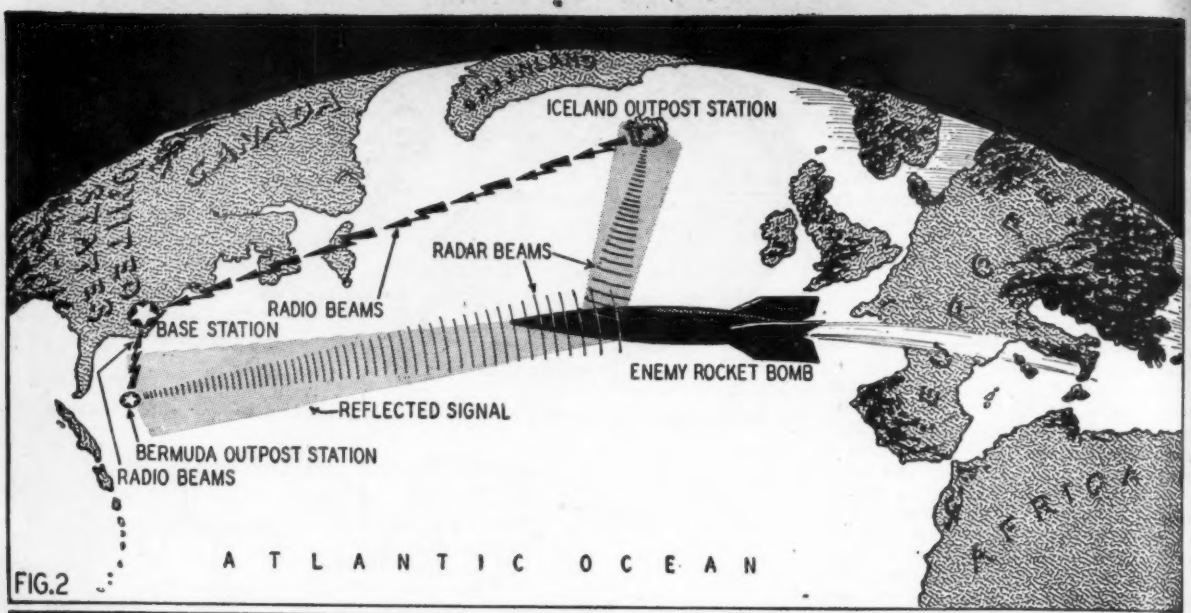



FIG.2

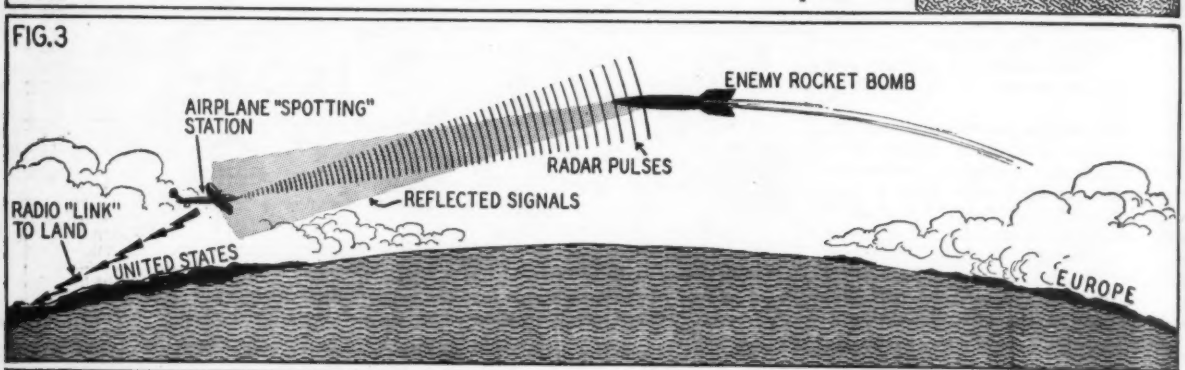



FIG.3

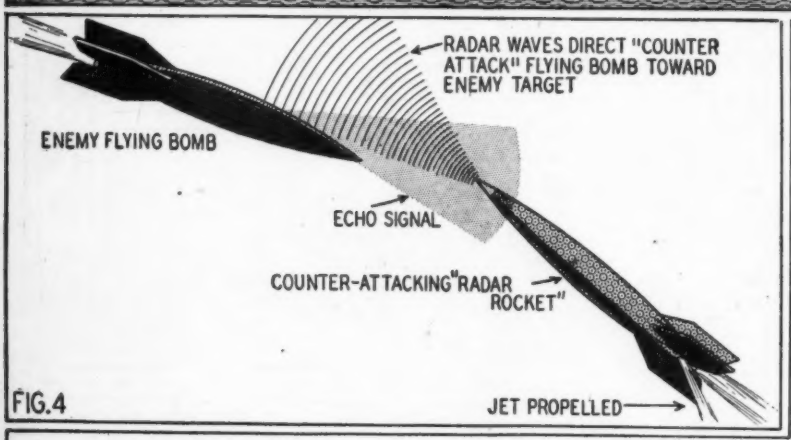
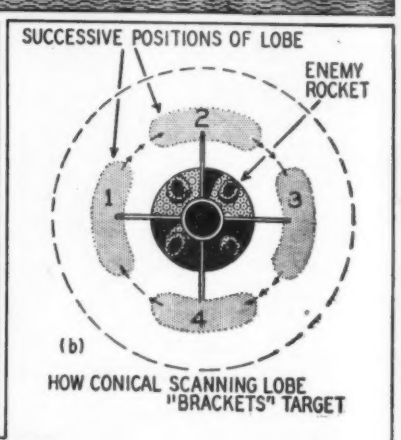

RADAR WAVES DIRECT "COUNTER ATTACK" FLYING BOMB TOWARD ENEMY TARGET
ENEMY FLYING BOMB
ECHO SIGNAL
COUNTER-ATTACKING "RADAR ROCKET"
JET PROPELLED

FIG.4




HOW CONICAL SCANNING LOBE "BRACKETS" TARGET

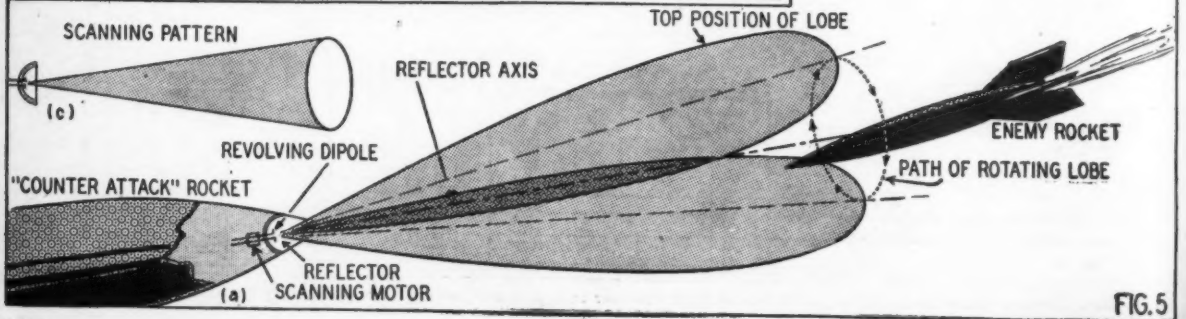



FIG.5

By H. W. SECOR

# RADAR ROCKETS

## *May Be the Answer to the Rocket Bomb*

ONE of the problems now engaging the attention of our military experts is to provide a strong defensive weapon to combat flying rockets and bombs. In the next war—should one occur—the enemy will loose a barrage of long-range rocket bombs on our cities and vital industrial plants. Some of these will doubtless be atomic bombs. High speed jet-propelled fighter planes may knock down some of them, but some surer way of fighting such an attack is needed. Counter-attack rockets immediately suggest themselves.

Microwave radars can be designed to direct the counter-attack rocket so that it literally chases the enemy rocket and explodes as it nears the missile, thus destroying it before it has a chance to reach its target.

Figure 1 shows a tentative plan for the positioning of the radar apparatus in the rocket, also the disposition of the explosive and the control mechanism.

It may be objected that the tremendous speeds of rockets may not allow time for such defense, but this is not the case. Even at a speed of 3,000 miles per hour, a rocket launched from the (for rockets) close range of 500 miles would take a minimum of ten minutes to reach its target. Actually the time taken would be much longer because of the curved trajectory. Trans-Atlantic rockets would travel much more than an hour.

The time allowed for launching the counter-attack rockets can be lengthened by erecting radar *outpost listening* stations at such points as Iceland, Greenland, Bermuda and other outlying places (also at similar Pacific stations) for spotting the approach of enemy rocket bombs. (Fig. 2.) These stations would be continually on watch. The information gathered by them would be relayed automatically to the main *base station* on the mainland by radio, and counter-attack radarockets sent out to apprehend the enemy missile and destroy it before it reached within striking distance of the mainland.

Another plan is shown in Fig. 3—an airborne long-range radar station. The flying radar station would maintain radio contact with the ground bases for transmission of target location data; an accurate location "fix" or position for the enemy rocket can be supplied at any moment, or its course may be plotted continuously. The station directing the radarocket can then combine the information received from two or more of these *spotters* to plot the coming rocket's trajectory and aim a fighter rocket in the proper direction to meet it. Electronic equipment could do all this automatically and the release would be almost instantaneous.

The radarocket would ascend rapidly, using jet propulsion. Upon approaching the target it could be detonated by the same means so successfully used in the thousands of *proximity fuze* shells employed against the enemy in the war just ended. In this device a radio wave was sent by the shell's miniature radio transmitter; reflected radio waves picked up from the enemy target (such as a plane) by the receiving set carried in the shell caused it to detonate when it came to within a distance of about seventy feet of the target.

In another plan the course of oncoming enemy missiles is plotted by radar and the launcher carefully aimed so the radarocket will intercept it. When this bloodhound of the air comes within a reasonable distance of the enemy bomb or flying rocket, it sends out a microwave which is reflected by the enemy missile (Fig. 4). These reflected waves are picked up by a receiver carried by the radarocket and keep it on the trail of the target.

This may sound far-fetched, but we have only to recall that some radars used in World War II would track an airplane in flight and automatically aim antiaircraft guns at it. These radars used conical scanning to achieve this feat.

The principle of conical scanning (Fig. 5) is that of using a reflector to concentrate or beam a pulsed signal in a *lobe* pattern—and then cause the lobe to rotate around the axis of the reflector.

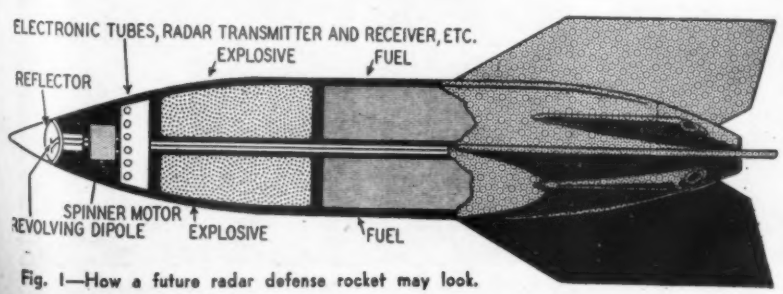



Fig. 1—How a future radar defense rocket may look.

**Harry Winfield Secor was born in Brooklyn, June 11, 1887. Studied electrical engineering in Philadelphia and New York. Worked as electrical inspector and power plant engineer 1910 to 1912. Has occupied many positions in the radio technical and journalistic world, among them: assistant editor MODERN ELECTRICS, 1910 to 1912; engineering department, Western Electric Co., 1912 to 1914; managing editor, ELEC-**

**TRICAL EXPERIMENTER, 1914 to 1919 (engineer to Electro Importing Co. during the same time, designing several arc generators, quenched spark sets and amplifiers); managing editor, SCIENCE AND INVENTION, 1919 to 1929. Lectured weekly on radio and popular science subjects over Radio WRNY, New York, 1926 to 1929. Was managing editor of SHORT WAVE CRAFT, AVIATION MECHANICS, TELEVISION NEWS, RADIO & TELEVISION, MODEL CRAFTSMAN, etc.**

**During his long career in radio writing, Mr. Secor wrote a number of books, including "How and Why of Radio Apparatus," "Induction Coil and Transformer Construction," "Simple Electricity Experiments" and was co-author with S. Gernsback and Austin Lescarboura of the "Wireless Course in 20 Lessons" (used in teaching many radio students in World War I).**

**Hobbies: Radio and Television set receiver construction; interpreting scientific subjects for the non-engineering reader.**

A tiny dipole antenna is mounted off-center in the reflector and is rotated by a small *spinner* motor. Only two successive positions (5-a) of the lobe are shown, for the sake of clearness. Note (5-b) that the rotating radio lobe projected by the dipole *brackets* the enemy target (a flying bomb for example).

Figure 6-a shows how the strength of the reflected echo signal from the target varies for different positions of the lobe, when the target is off the center-line of the reflector. When the target is on the reflector center-line (6-b) the strength of each reflected signal is of equal amplitude. Thus the pulsed signal actually scans the target.

The varying strength of the reflected signal actuates a correcting mechanism (operating the vertical and horizontal rudders, or firing "course-correcting"

*(Continued on page 720)*

COVER FEATURE

# NEW FACSIMILE IS FAST

## *Home Radio Newspaper Can Be Combined with FM Receiver*

IT IS more than possible that the morning paper of the future may be started printing by an automatic relay set to turn on the facsimile printer at four or five o'clock in the morning, and completing news, fashions, sports, comics and picture section before breakfast time.

Mr. Hogan stands directly behind the transmitter's scanning drum.

How the newspaper is delivered from the home facsimile receiver.

Facsimile transmission is by no means new, and has been used for both wire and radio transmission of pictures, drawings and printed matter. During the war radio and wire facsimile systems transmitted maps and drawings which could not have been sent instantaneously by other means. RADIO-CRAFT in particular was interested in the "radio newspaper" and the April, 1934 number pictured such a receiver on its cover and devoted an article to the subject.

One serious drawback prevented the radio newspaper from becoming an actuality. Speed of transmission was fatally slow—from 30 to 50 words per minute. The new system developed by J. V. L. Hogan, produces copy at over 250 words per minute—faster than the pace of the average reader. The actual paper speed is 28 square inches per minute, words or picture copy. This amounts to over four 8 x 11½-inch pages per 15-minute facsimile broadcast period.

The facsimile broadcaster described here is designed to operate in conjunction with an ordinary FM transmitter. A steady 10,000-cycle note is modulated by light reflected from the matter to be transmitted, the actual modulating frequencies running up to 3,000 cycles. These modulate the 10,000-cycle note, producing a band from 7,000 to 13,000 cycles. The transmission is audible as a high-pitched, varying whistle.

The varying note is applied to a standard FM transmitter and transmitted, received and detected by standard FM methods. The signal is then fed into the facsimile receiver and made to reproduce the original visible matter.

The console shown consists of two scanning drums for transmission of the material, and two monitors. The one at the left monitors the output of the transmitter constantly,

*(Continued on page 707 )*

One side of transmitter console. Photo at top shows other side.

By H. B. CHURCHILL

# BROAD-BAND ANTENNA

## *Arrays adapted to V. F. Transmissions*

MULTI-ELEMENT close-spaced rotary-beam transmitting antennas are today one of the most widely used arrays for amateur operation. There are a number of good reasons why.

First of all, they're compact: they occupy a tenth the space of a long-wire system of comparable gain, and are therefore ideal for apartment house or other installations using the smallest possible space.

Another thing, they can be pointed in any great circle direction with ease, and concentrated on any given station within a few moments' notice, a feat impractical if not impossible with long-wire arrays. Their gain in delivered microvolts-per-dollar is extraordinary in comparison with expensive increases in transmitting apparatus.

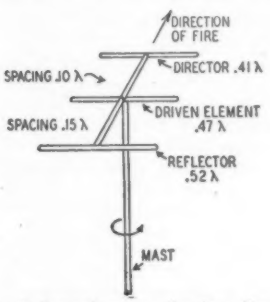



Fig. 1—3-element array, showing dimensions and spacings for 15 percent more bandwidth.

From a technical as well as a practical standpoint there is one serious shortcoming to the ordinary multi-element close-spaced array: its gain and compactness depend upon close spacing between antenna elements, which in turn exacts a heavy *penalty* in the form of frequency response. Erect a three-element beam for amateur operation on 28,500 kcs, let's say. Properly adjusted, it performs excellently at that frequency. But deviate from that frequency very much and gain rapidly falls off, radiation patterns shift, impedances become mismatched, and severe losses appear in the line.

This same effect applies to high-gain antennas for long distance short-wave reception alone. Let's say you've erected a rotary for extreme broadcast DX on or about 15,000 kcs. You find that Saigon comes in very well on 15,125 kcs, but experience shows great difficulty with All-India Radio on 15,450 kcs. The reason: your antenna gain has fallen way off at that frequency, with India's signals far down in static and tube noise. You may well attribute such poor reception to "conditions," but it's likely to be your array which, performing excellently on the frequency you designed it for, simply won't work well *off* that frequency.

Now, there are two interesting technical features in a three-element close-spaced beam. Your director element, placed in front of the driven element (to which feeders connect) leads the signals forward when transmitting. Your reflector acts in concert to screen signals from travelling to the rear, and reinforces the forward radiation. The relationship is complex, but that's about it in simple terms.

To act as a director your first element must present capacitive reactance to the center driven element, and thus be electrically shorter. The reflector must present inductive reactance, and thus be electrically longer. As you shift frequency, your rod and element length naturally doesn't and can't change. Shift your frequency far enough and the electrical relationship between elements so radically changes that the antenna is no longer a beam but merely a collection of pipe.

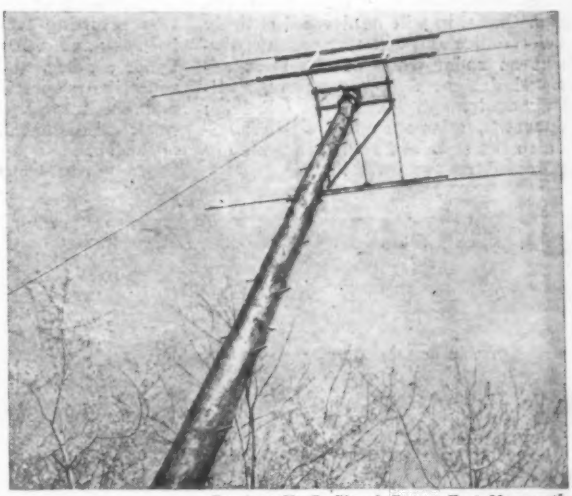
If you could take a week or so off to concentrate on the higher math involved in the problem you'd find five or so interlocking variables which, with further analysis on the subject, would lead you to the fact that if certain carefully derived lengths were found and used, these variables would shift in equally opposing directions over a far greater number of frequencies. You'd thus find your useful frequency range would be broadened several times. Putting into practice these figures not only allows you to have a high-gain array on a center operating frequency, but one which will provide high gain over a good segment of the dial.

Measurements show that the average three-element close-spaced amateur array has an effective frequency response of about 2 percent of the frequency for which it's designed until a 2 to 1 standing wave ratio appears on the line, materially reducing its performance. This improved broad-band array, however, has a measured frequency response of 15 percent before a similar standing wave ratio appears. It provides a measured gain of 5.6 db over a comparison dipole at the same height above ground (in most measurements 3 wavelengths). Measured front-to-back ratio is 16 db, horizontal pattern covering 35° each

*(Continued on page 727)*

**Major Harold B. Churchill, after vagabonding around Europe for a few years, attended Princeton University. In 1930 became a floor member of the New York Stock Exchange for his own securities firm. In 1935 became active in oil well drilling and geophysical research, two years later becoming one of the editors of Time Magazine. Subsequently a contributor to**

**Colliers', the Reader's Digest and other publications, was attached to the Signal Corps Laboratories and the Signal Corps Publications Agency during the war, where he wrote and was in charge of the editing of technical manuals covering radio equipment. Main hobby is amateur radio operation, having held the calls 1AOA, 1BJZ, 2API, 2APO, 3ZJ, W1ZC, and his present call, W2ZC.**



*Courtesy U. S. Signal Corps, Fort Monmouth*

Spacing and dimensioning can make arrays like this more versatile.

BY E. A. WITTEN

# RADIO IN THE ATOM TESTS

## *Electronic Specialists Will Learn Much at Bikini Atoll*

PROBABLY the most elaborate scientific tests ever carried out as far as the number of people, amount of equipment and total expense are concerned will be the atomic energy tests this summer. For the gigantic task of measuring and determining the amount of damage an atomic bomb can do, Joint Army-Navy Task Force One will send three elaborately equipped laboratory ships to Bikini Atoll (Fig. 1). These ships will carry many of the nation's top-ranking scientists with all equipment and instruments necessary for conducting the tests. One ship will be devoted entirely to electronics and will carry such equipment as radar units of the most advanced design, Geiger counters, radiology equipment, long-range television apparatus, seismographs; all in addition to the standard radio transmitting and receiving apparatus.

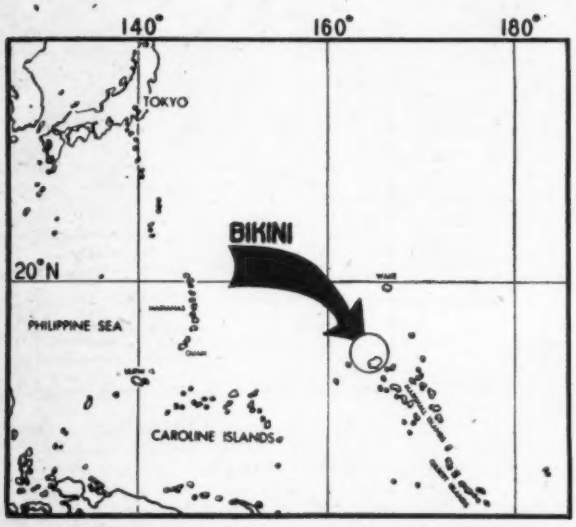



Fig. 1—Bikini was selected for its remoteness from land areas.

The technical staff will consist of over 1000 technicians. These men will be divided up into nine specialist groups or divisions: bomb operation; blast pressure and shock; wave motion and oceanography; electromagnetic propagation and electronics; radiological safety; radiometry; radiation; remote measurements; and technical photography.

In the field of wave motion, supersonic echo sounders will measure the vertical motion of both the target ships and the buoys at a distance from the explosion, while pressure recorders on the bottom will record water depth versus time by measurement of hydraulic pressure. In addition, seismographs will be set up on the islands around the atoll to observe the propagation of shock waves through the earth and thus obtain information on the geological structure of the atoll.

The electromagnetic propagation and electronics division will make studies of the effect of the atomic bomb explosion on the propagation of electromagnetic waves. These tests are planned to show the influence of the intense local ionization resulting from the detonation on both *sky* and *ground* wave transmission. Other experiments will show the radar reflective properties of the bomb cloud and the intensity of the atmospheric electrical disturbances developed by the explosion.

Standard Navy, Signal Corps, and Air Force radar equipment as well as special devices constructed for the tests will be used to measure electromagnetic propagation. The area to be tested, the distance covered by the blast, and a time base are shown on the diagrammatical chart in Fig. 2.

Army Air Force "drones" will carry Geiger counter warning circuits and special transmitters to determine the effect of the bomb explosion in the 5-to-9-megacycle region. It is not known at present what effect the bomb cloud will have in radio or radar interference or reflection.

The radiological safety section is charged with protection of personnel from radiological hazards after the blast. This includes responsibility for measurement of radiological phenomena in the areas to be entered by various personnel and for tracking the movement of radioactive air and water masses caused by the explosion. The primary safety device is the Geiger counter which indicates radioactivity by a clicking sound, a cathode-ray tube or the movement of a hand on a dial. Additional safety devices are ionization chambers, specially sensitized films, and chemical capsules which indicate *total* radioactivity from the measurement of *induced* radioactivity.

Radiometry is the subject of study of another staff section. Radiometry is defined for the purposes of the atom bomb tests, as a measurement of light in the visible spectrum and adjacent wave bands (ultra-violet and infra-red). This is distinguished from the staff section which is concerned with

*(Continued on page 716)*

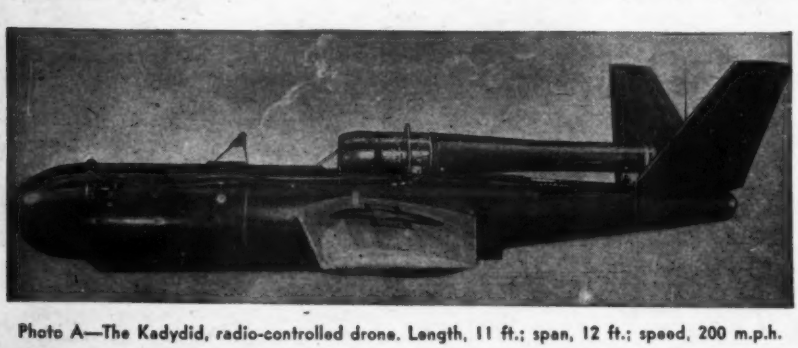


Photo A—The Kadydid, radio-controlled drone. Length, 11 ft.; span, 12 ft.; speed, 200 m.p.h.

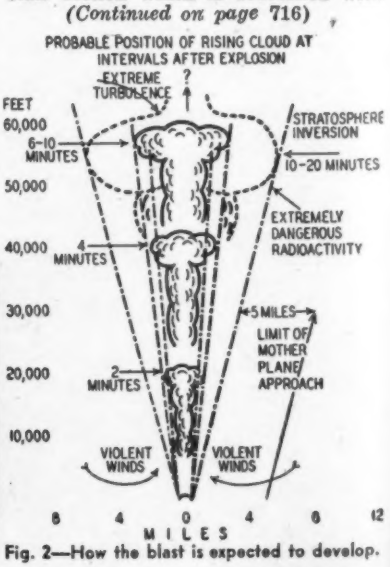



Fig. 2—How the blast is expected to develop.

By MILTON S. KIVER

# TELEVISION FOR TODAY

## *Part II—Scanning Tubes and Methods*

WE HAD a general, overall view of a television system in the previous article. Now let us concentrate on the action within a television camera. Then we will go to the receiver and examine each section in detail. The camera is chosen first because unless we understand its operation, much of what is done at the receiver is meaningless.

An *Iconoscope* camera tube is shown in Fig 1. The scene is focused by an optical lens system onto a mosaic plate within the tube.

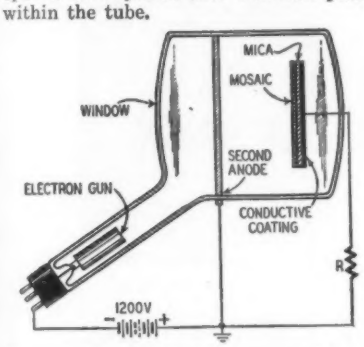



Fig 1—Cross-section of Iconoscope. Second anode is a ring round the inside of the tube.

The plate consists of a thin sheet of mica (an insulator) upon the front of which has been deposited a single layer of microscopic globules of a sensitized caesium-silver compound. In the process of construction each globule tends to dissociate itself from all the other globules, much as water acts when poured over an oily surface. Electrically, then, any change that affects one globule will not affect any of its neighbors.

Each caesium-silver globule reacts to any incident light, causing emission of electrons. Thus, the televised scene, in being converted to electrical charges, is automatically broken down into a series of minute elements, much like the grains of a photographic strip of film. This is the first step in the process of converting the light rays into equivalent electrical currents. At each point, the electrons emitted from a globule will be directly dependent upon the intensity of light. Since each globule is electrically independent from all the others, all variations in light intensity at different points in the scene will be in like measure changed to electrical charges.

The electric charge on each globule is utilized through a scanning electron beam and a conductive coating located on the reverse side of the mica mosaic plate. The electron beam, generated in the neck of the Iconoscope, is forced by deflection coils to sweep across the mosaic plate in a series of lines as indicated in Fig. 2. As the beam passes over each globule it replaces the electrons lost due to the light rays. Since each globule tends to form a charged condenser (with the second plate the conducting surface on the other side of the mica), replacement of the lost electrons acts to discharge this condenser combination, with the formation of a pulse of current through the load resistor R shown in Fig. 1. Hence as the beam sweeps along, it sends fluctuating pulses of currents through R, each pulse varying proportionately as the original light from the scene. We have thus completed the transformation of light into equivalent electrical video currents. These currents are amplified and used to modulate a fixed carrier to form the transmitted signal to be picked up by the receiver.

### ELECTRON BEAM SCANNING

The image formed on the mosaic can be analyzed by several methods. We can break the image down into a series of horizontal lines, as shown in Fig. 3-a, a series of vertical lines, as shown in Fig. 3-b, or by means of an ever-widening spiral, as in Fig. 3-c. Of these three methods (and there are many more), horizontal scanning has been adopted as standard. In this method, the scanning beam starts at the upper left-hand corner and progresses to the right until the edge of the mosaic is reached. From this point the beam must be quickly brought back to the left-hand side and the left-to-right scanning sweep begun again. The retrace motion must be as quick as possible, for during this time the beam is completely blanked out and no information appears on the screen. The sequence of left-to-right

Photo A—A Farnsworth image dissector tube.

sweep of the beam, when information is being traced out on the screen, plus rapid retrace while the beam is getting in position for the next line, is repeated over and over until the bottom of the image is reached. From here the beam is brought back to the top of the image, and the entire sequence repeated. Fig. 2 indicates the method pictorially.

The above description explains the

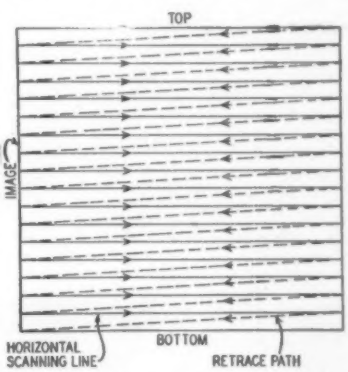



Fig. 2—Electron beam path, simple scanning.

method in use today. For ease in operation and to present a smoother image at the receiver, two modifications have

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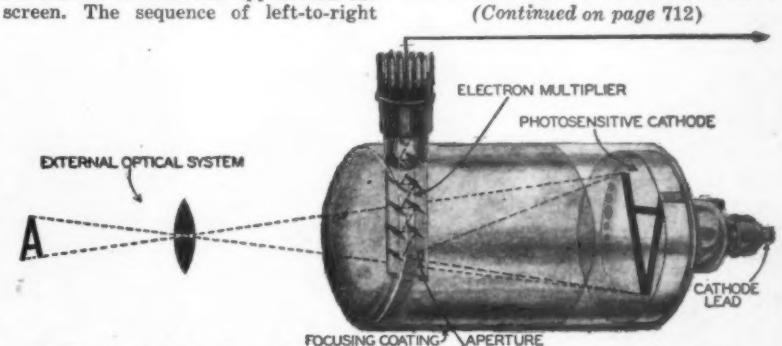


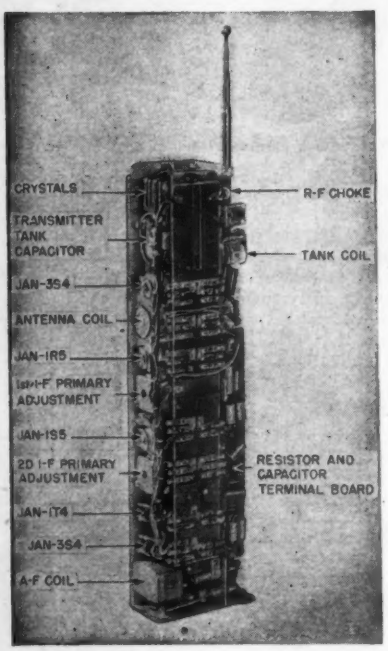

In the dissector tube, the whole electronic image field is "scanned" past the aperture.

By ROBERT F. SCOTT, W4FSI

# INSIDE THE HANDIE-TALKIE

## *War's Smallest Two-Way Radiophone*

THE Handie-Talkie is perhaps the most widely known and well liked radio set developed during the war. Its efficiency at short ranges and its compactness created a demand for this set in practically all branches of the service. Called by the Signal Corps "Radio Set SCR-536", the Handie-Talkie is built into a metal case 3⅝ x 5⅜ x 15¾ inches long. This space contains a receiver-transmitter complete with batteries, microphone and earphone. Compactly built and weighing but 5½ pounds, it permits the operator to use it like a French type telephone.




This chassis view shows the main components.

The SCR-536 is designed for two-way voice communication over distances up to one mile. The effective range is often decreased by terrain features like hills, steel buildings, heavily wooded areas and power lines located between the two stations. On the other hand, the range may be increased by locating the transmitter on the top of a tall building or a hill where the signal will have an unobstructed path to the receiver. Foolproof net operation is made possible by using crystal control in the receiver and transmitter circuits. This feature permits instant operation by untrained operators who would not be able to make frequency adjustments on other types of sets. These sets may be tuned to practically any predetermined frequency between 3500 and 6000 kc by the selection of proper coil and crystal combinations. Frequency changing in these sets is done by men who have been trained to do this work.

Operation is further simplified by the omission of several conventional controls. The only ones on the set are the "on-off" switch and a fingertip operated "push-to-talk" button. The "on-off" switch is mounted inside the set and is operated by the telescoping antenna. When the antenna is fully extended, the switch is thrown on and when retracted, is automatically turned off.

By careful selection of operating frequencies, these sets may be used in nets with such other sets as the SCR-245 and SCR-193 which employ variable frequency control and may be tuned to the frequency of the SCR-536.

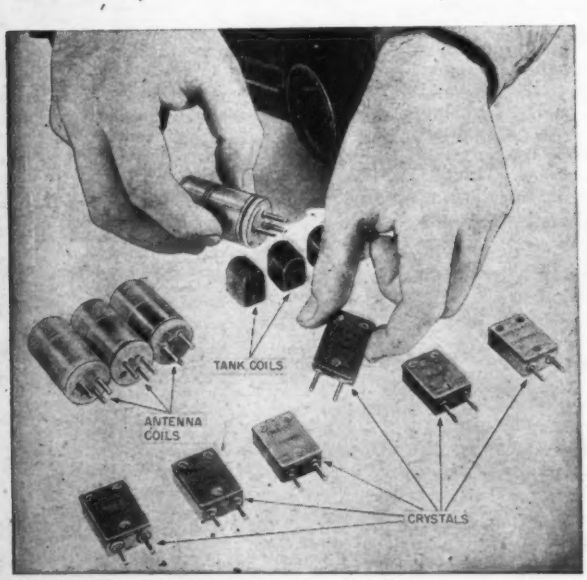
Antenna switch detail.

### HOW IT OPERATES

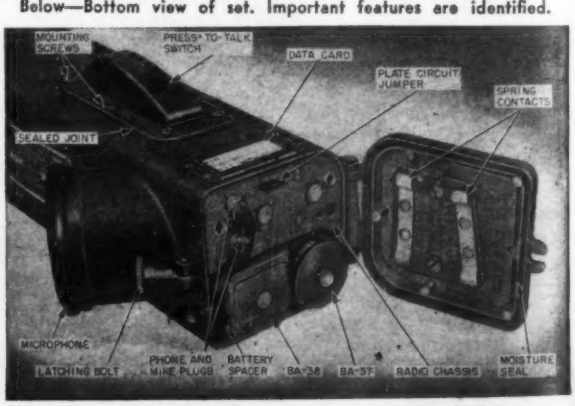
The receiver portion of the set uses a conventional superheterodyne circuit with a 3S4 r.f. amplifier, a 1R5 oscillator-mixer, 1T4 i.f. amplifier, 1S5 second detector, first a.f. amplifier and a.v.c. A 3S4 audio amplifier supplies approximately 0.18 watt to a small dynamic earphone.

The grid circuit of the r.f. amplifier is tuned by a series combination of

*(Continued on page 703)*




Left—Coils and crystals for changing Handie-Talkie frequencies.
Below—Bottom view of set. Important features are identified.



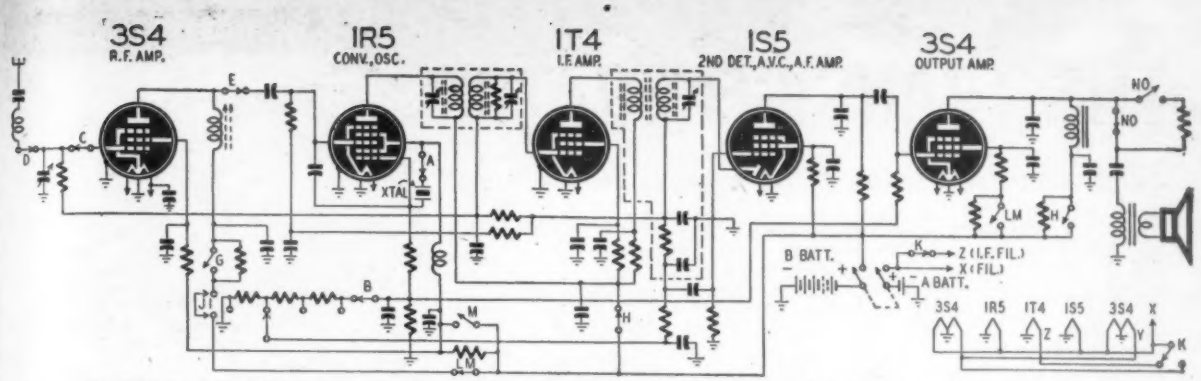



Fig. 1—Handie-Talkie switched to the "receive" position. Letters refer to switches shown in schematic form in the drawing below. Note that only one side of the two 3S4 filaments are heated when the set is used as a receiver. Tuning is controlled by the oscillator crystal.

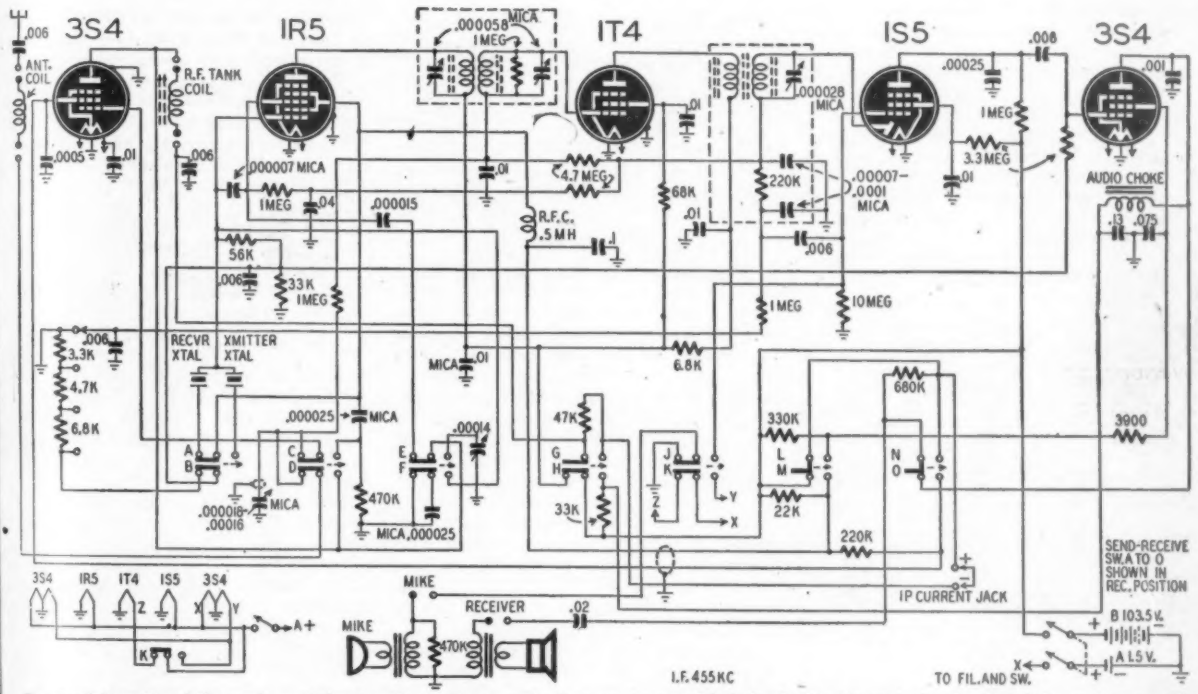
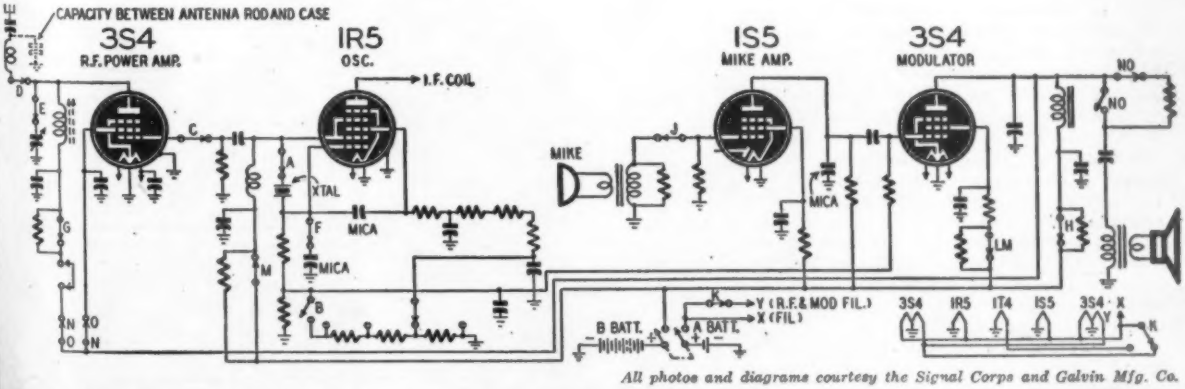



Fig. 2—Schematic of the war's most famous piece of communications equipment. Made by Galvin Motorola for the Signal Corps, it was used "in the air, on land and on the sea." Each set employs two crystals ground to frequencies 455 kc apart. The 1R5 acts as a Pierce oscillator in both transmitting and receiving circuits. The 14-section changeover switch is lettered to agree with the other two figures. Early Handie-Talkies had crystal earphones, but later ones used the inductor type illustrated in these diagrams.




*All photos and diagrams courtesy the Signal Corps and Galvin Mfg. Co.*

Fig. 3—As a transmitter, the Handie-Talkie is a four-tube set. The 1R5 functions as master oscillator in a Pierce circuit, driving one of the 3S4's as r.f. power output tube. The 1S5 and the other 3S4 are speech amplifier and modulator, Heising system being used.

By ROBERT E. ALTOMARE

# THE TRANSIGENERATOR

## *Signal Generator Employs New Circuit*

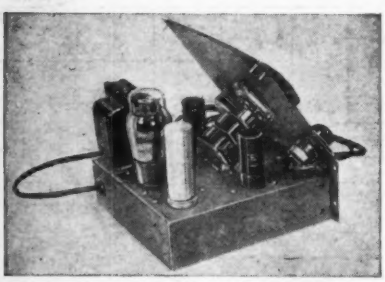
Photo A—The Transigenerator as seen from the front.

NEXT to a good multimeter, the signal generator is probably the electronic technician's most useful piece of test equipment. In addition to its familiar function as a signal source for purposes of alignment, it may be used for signal substitution and in conjunction with other instruments for many types of measurements.

A well designed signal generator is an investment for the professional service technician, but is a costly item to the experimenter or beginner who has but occasional use for the instrument. He would often prefer to build his own if a reasonably efficient unit could be turned out. Unfortunately, to be at all usable, the signal generator must be a highly stable, precision device. The complex design factors make it difficult to get these desirable characteristics in a home-built model.

### TRANSITRON SIMPLICITY

It is possible, however, for even the careful beginner to construct an efficient signal generator of the utmost simplicity. It is only necessary to make use of an oscillator circuit which has been repeatedly neglected by the practical



Rear view of the transitron signal generator.

man since its inception. That oscillator is the *Transitron.*

The basic circuit is shown in Fig. 1. Operation depends upon the fact that any slight change in screen voltage is transmitted in like polarity to the suppressor grid. An increase in suppressor voltage *reduces* the screen current and vice versa. Thus a negative resistance effect is observed at terminals x-y. A resonant impedance—such as an L-C tank circuit—connected between x-y will cause the circuit to oscillate at the natural resonant frequency of L and C. The article, "Transitron Oscillators," in the April, 1945, issue of RADIO-CRAFT, gives an excellent account of the theory and operation of this circuit.

The advantages of the Transitron are:

1—Extreme simplicity.
2—Unusual stability easily obtained.
3—Good wave form the rule rather than the exception.
4—Two-terminal coil usable (i.e. no critical coil tapping).

### THE TRANSIGENERATOR

The above advantages have been combined in the instrument whose circuit is shown in Fig. 2. Two tubes (plus rectifier) are employed—the r.f. and the a.f. oscillators. For modulated r.f. output, the a.f. oscillator grid-modulates the r.f. circuit which then also functions as a mixer. Circuit voltages and electrode currents are given in Fig. 2. Pictorial views are shown in the photos.

### THE R.F. OSCILLATOR

The r.f. unit employs the type 6SK7 remote cut-off pentode. The tuned circuit is placed in the suppressor rather than the screen circuit to permit grounding of the tuning capacitor rotor (it could have been placed in the plate or cathode circuit with no change in operation). Note that this stage operates with a plate potential of only 9 volts, while the screen potential is +50 volts to ground. Considerable deviation is allowable, but it is suggested that the constructor use the voltages shown. The r.f. output attenuator consists simply of a variable suppressor-bias resistance R1 in the cathode circuit. The 400-ohm fixed cathode resistor sets the operating point and precludes waveform distortion.

The tuning capacitor C is of the dual-gang variety; the capacity of each section ranges from 30-350μμf. Switch S1 chooses tuning inductance L1, L2 or L2 plus L3 and hence selects the frequency range. The ranges are approximately: Band A—160 to 660 kc; Band B—550 to 2000 kc; Band C—2 to 8 mc. Additional ranges may be added.

To obtain the ranges given, a one millihenry r.f. choke is used for L1. L2 and L3 are wound on the same ⅝-inch coil form to save space. L2 has an inductance of 25μh and consists of 17 turns of No 30 enamel wire. Winding length is 3/16 inches. Inductance L3 is 120 μh and it is wound with 120 turns of No. 30 enamel wire. The winding length is 1 5/16 inches. A permeability-tuned manufactured coil could be substituted for L2-L3 and then adjusted to give the range desired. It was considered more expedient to wind coil L2-L3, this being a simple matter.

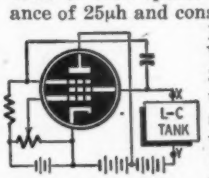



Fig. 1—Basic circuit.

The 8-mc upper frequency limit was considered adequate for most purposes; and the second harmonics of band C have been used to extend the range to 16 mc. Use of the third and higher harmonics is not feasible because of the Transigenerator's relative purity of wave form.

The r.f. output is taken directly from the suppressor grid through the 25-μμf isolating capacitor. This capacitor not only blocks d.c. but also prevents de-

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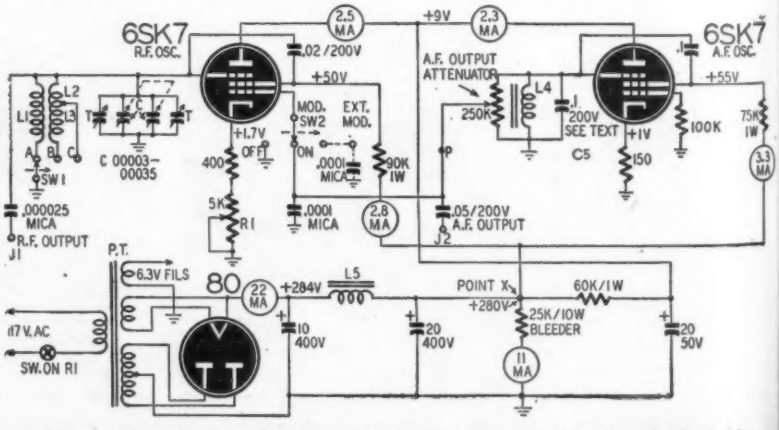



Fig. 2—Schematic of the Transigenerator. Single coils are used in r.f. and a.f. circuits.

By I. QUEEN, W2OUX

# 430 MC WITH A 6F4

## *Coaxial-Cavity Transmitter for the Ultra-Highs*

MICROWAVES demand designs which are not practical at lower frequencies. For example, above 400 mc, the coaxial oscillator with its relatively large conducting surface is one of the most practical circuits. Tubes used at these frequencies also show novel design. These tubes are generally triodes. At the very high frequencies, one type of construction uses *two leads* to both the control grid and the anode. The RCA 6F4 acorn is such a tube. Some advantages of these unconventional designs are:

The coaxial oscillator eliminates undesirable radiation from the coil or open lines. Such radiation results (unless the complete circuit is shielded) in lower Q, less power output and greater instability. Unfortunately, some coaxial circuits are difficult to construct and the frequency cannot be changed as readily as in other types.

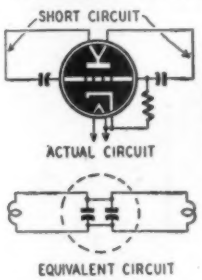



Fig. 1 — Actual and equivalent circuits of 6F4 double-lead tube.

The double lead tubes reduce internal lead inductance and element capacitance. As a result it is possible to obtain more external inductance in the tank coil or the lines. Amateurs who have experimented with ordinary (high C) tubes know that in some cases there is almost no inductance outside the tube which can be used to couple to the antenna. The actual and equivalent circuits using a double-ended tube are shown in Fig. 1.

The coaxial oscillator using a type RCA 6F4 described here is not difficult to construct and gives more output than the transceiver described in the May issue. The 6F4 is designed to oscillate as high as 1200 mc with 150 volts on the plate. The principle of the oscillator is easy to understand. There are two hollow cylinders, one of small diameter and the other large. The first slides within the second to vary the effective line length and therefore the frequency. One end of the oscillator is shorted. The open ends of the two cylinders connect to the tube elements.

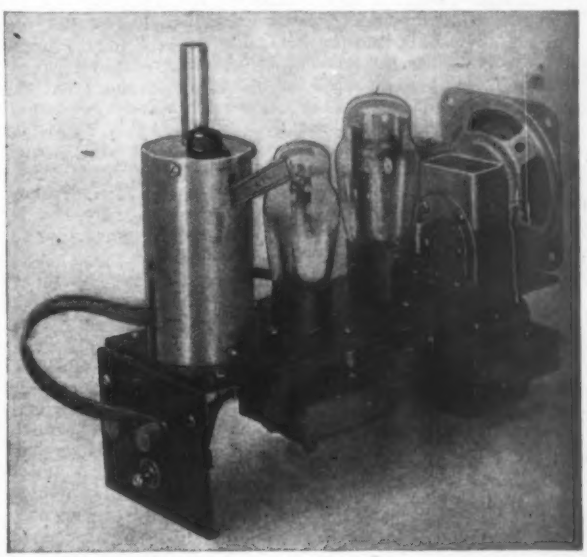
Not only is direct radiation (from the coaxial) eliminated, but the relatively large surface area greatly reduces circuit resistance. For further reduction, the metal parts of this oscillator were silver-plated. Another important feature is that r.f. travels only along the inner surface of the larger cylinder, leaving the outside at ground potential when suitably by-passed. No r.f. choke is required in the plate circuit.

### THE COAXIAL UNIT

The essential parts of the oscillator are (see photo):

1—Tube and socket
2—Circular piece of polystyrene
3—Brass ring
4—Inner cylinder
5—Outer cylinder
6—Metal short-circuit between cylinders

1—The 6F4 tube is shown in its socket in Photo B. The 7-pin socket is a type XLA (National Co.) made of low-loss R-39 and is small enough to fit entirely within the outer cylinder. The circuit components are mounted on the socket as shown. The grid condenser and grid resistor are side by side. One end of each is soldered directly to the grid terminal. The other end of the resistor connects to a filament terminal, while the other end of the condenser is held by a screw which passes through the socket. The second set of grid and plate leads are connected together through a 50 μμf condenser with about



Complete transmitter. Speaker is a.f. oscillator coil and monitor.

1-inch leads. This, together with internal leads, resonates at the frequencies used, and is equivalent to the other set of lines (Fig. 1). The cathode is connected to one filament terminal. The two filament leads are made of about 7 inches of Amphenol twin-lead 300-ohm cable. This is a half-wave length section and therefore removes the necessity for r.f. chokes which are more difficult to handle. This section must be terminated with a by-pass condenser.

2—This is made of quarter-inch polystyrene approximately 1 13/16-inch in diameter. The socket is mounted on it with machine screws. The poly must be tapped for these screws. In tapping, exercise caution as the particles accumulate and harden due to the generated heat. If the tap is forced, it may break. It is better to work a little at a time and clean the tap before proceeding further. A half-inch hole is drilled through the center of the polystyrene disc.

3—This ring is 1⅞-inch in diameter

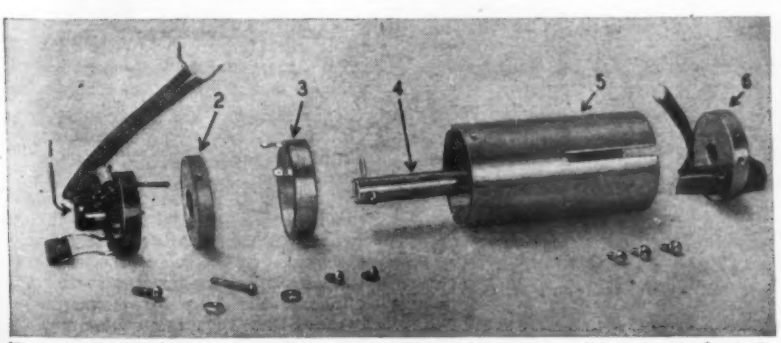
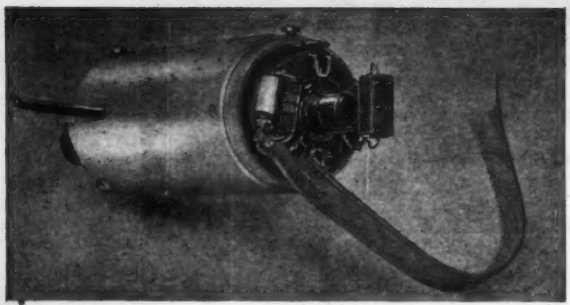



Photo A—Exploded view of resonant cavity. Numbered parts are referred to in the text.



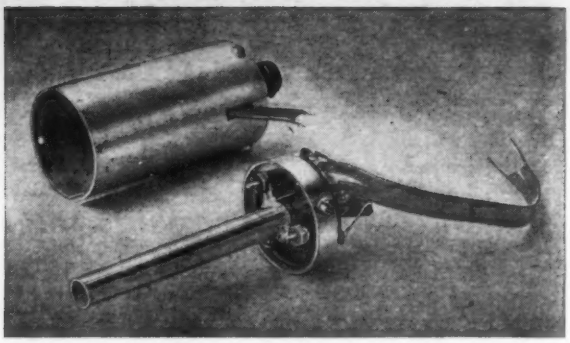


Photo B (above) and the accompanying photograph show construction details of the coaxial cavity oscillator section and 6F4 mounting.

and 5/16-inch high. Screws hold it in position around 2, the latter being tapped. The function of this piece is to slide within the outer cylinder and form the terminal for connection to the plate. Parts 3, 4 and 5 are made of silverplated 1/16-inch brass.

4—This is the inner cylinder. It is 3½ inches long and has a diameter of ½ inch. One of the ends (left-hand end in the photo) fits into the hole through the polystyrene. A hole is drilled through this cylinder just below where it fits into the polystyrene. Through this hole is passed a piece of No. 18 wire, the ends of which are bent to form small loops. Two of the screws which hold the socket to the polystyrene also pass through these loops and are

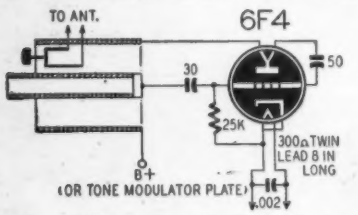



Fig. 2—Oscillator schematic. The B-plus lead connects to the plate of the tone oscillator.

tightened in place by nuts. Parts 1, 2, 3, and 4 are thus held together as one unit, and make a sliding assembly. It was mentioned in 1 that one end of the grid condenser is held by a screw through the socket. Since this screw contacts the No. 18 wire, it also makes contact with the inner cylinder. The wire should be soldered to the cylinder where it enters on both sides.

5—This is the outer cylinder, which also shields the entire unit. It is 3½ inches long and has an outer diameter of 2 inches. This part, like the two others, is made of 1/16-inch brass and silver-plated. Two slots (as shown on the photo) are filed at one end. These are guides for the two screws which extend from the brass ring 3. These screws (which pass through the poly) can be tightened down against the outer cylinder after the correct position of the sliding assembly has been determined.

Fig. 3.

6—This is the short-circuiting part, made of brass 1⅞-inch in diameter and 5/16-inch thick. A ½-inch hole is drilled through its center to accommodate the inner cylinder. To provide a good electrical connection the hole should be drilled carefully, and through the *exact* center. The large contact surface, silver-plated, reduces resistance to a minimum. This part is attached to the outer cylinder by screws which pass into tapped holes. One of these screws is long enough to pass completely through and exert pressure on the inner cylinder. Thus, when the proper position of the latter is found, it may be tightened into place and a good connection assured. Schematic is shown in Fig. 2.

## FREQUENCY, COUPLING, ANTENNA

With the dimensions given above, the oscillator will operate from about 400 mc to over 600 mc. This covers not only the present and prospective amateur bands (420-450) but the Citizens' Band which will probably open in the near future (460-470 mc).

Most important constants for the 6F4 tube are:

Filament power .....6.3 volts, 225 ma
Plate voltage .....150 max. volts
Plate current .....20 max. ma
Grid current .....8 max. ma
Plate dissipation .....2 max. watts
Grid voltage ..... 50 max. volts

Its socket connections are shown in Fig. 3. It is intended for frequencies as high as 1200 mc in suitable circuits, and has a closely spaced electrode structure. At moderate frequencies it is capable of 1.8 watts output, with .2 watts of driving power.

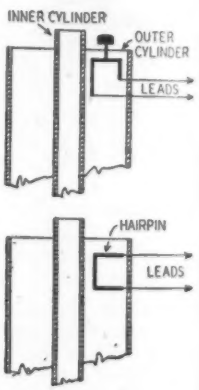
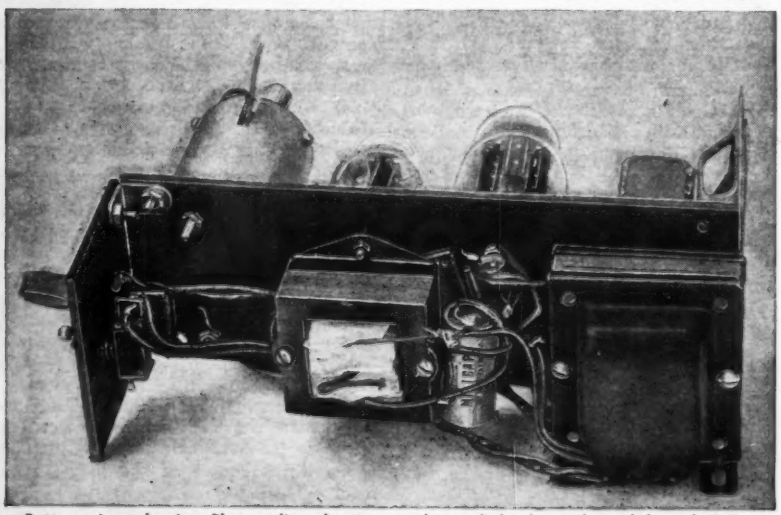



Fig. 4—Two methods of antenna coupling.

Frequency oscillation may be checked by Lecher wires as explained in previous issues of RADIO-CRAFT. The no-load plate current may vary somewhat, depending upon the individual construction and component values, but should be 8 ma or less. With a load it should rise to about 16 ma or more. The plate will get red-hot if the maximum of 20 ma is greatly exceeded. With this setup no appreciable drop in efficiency could be detected over the entire range of frequencies covered.

There are two possible means for coupling to an antenna with this oscillator. These are illustrated in Fig. 4. One uses a U-shaped piece of copper which can be rotated over a limited angle with the small knob and polystyrene rod at the top of the oscillator. When its sides are closest to the two cylinders, the coupling is maximum. Twin-lead or coaxial cable may be

*(Continued on page 705)*



Bottom view, showing filament-line shorting condenser behind switch on left end-piece.

By ARTHUR HOWARD & MORRIS EDDY

# MATHEMATICS–RADIO TOOL

## *Part II—Shunts and Multipliers; Matching Loudspeakers*

KNOWLEDGE of mathematics is useful in servicing electronic apparatus as well as in designing it. For example, a technician, servicing a television receiver using a 12-inch cathode-ray tube, finds the intensity of the image too low. He suspects a short circuit in the high-voltage supply. If the tube used is a 12AP4 at 7,000 volts on the second anode, with a bleeder network current of 2 ma, what resistance value across the bleeder network should he expect to find? (Fig. 1).

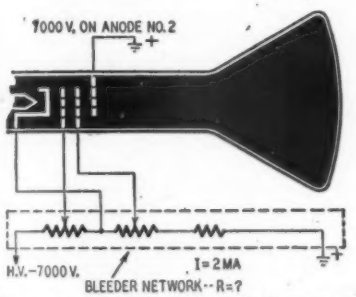



Fig. 1—A safe way to check high voltages.

The problem is readily solved with mathematics and Ohm's law.

$R = E/I$ where R = resistance in ohms, E = the voltage in volts and I = current in amperes.

Substituting—

$$R = \frac{E}{I} = \frac{7{,}000}{.002} = 3{,}500{,}000 \text{ ohms}$$

$$= 3.5 \text{ megohms}$$

Hence, the value of the bleeder network resistance should be 3.5 megohms. Any large deviation from this figure probably denotes a short-circuit in the bleeder network.

Armed with the versatile 0-1 milliammeter, the radio worker can extend its range by using suitable shunts and resistors. To solve for their values, only paper, pencil and easy mathematics are needed.

A technician desires to increase the current and voltage ranges of his 0-1 milliammeter to 50 ma and 150 volts, respectively. The internal resistance of the meter is 27 ohms. What will the resistance values of the shunt and multiplier resistors be?

Firstly, we solve for the shunt resistor. (Fig. 2, left):

$$R_x = \frac{R_m}{n-1}$$

where $R_x$ = the resistance of the shunt, $R_m$ = the internal resistance of meter and n = scale multiplication factor.

Substituting—

$$R_x = \frac{R_m}{n-1} = \frac{27}{50-1} = 0.552 \text{ ohm}$$

Now, to solve for the series multiplier resistor (Fig. 2, right), we use the following formula—

$$R = \frac{1{,}000 \times E}{I}$$

where R = value of the multiplier resistance, E = the desired full-scale voltage and I = the normal current capacity of meter in milliamperes.

(Note: For practical purposes the internal resistance of an 0-1 milliammeter may be disregarded when calculating the multiplier resistor, unless the scale be exceptionally low or the meter resistance large.)

Substituting—

$$R = \frac{1{,}000 \times E}{I} = \frac{1{,}000 \times 150}{1}$$

$$= 150{,}000 \text{ ohms}$$

Thus, if we insert a shunt resistor of 0.552 ohms, the new full-scale current range will be 50 ma. Likewise, with the introduction of a 150,000 ohms series multiplier, the full-scale voltage becomes 150. With a suitable choice of shunts and multipliers, we can build a multi-range volt-milliammeter with any desired number of ranges.

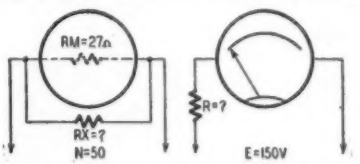



Fig. 2—Meter shunt, left; multiplier, right.

### SPEAKER COMBINATIONS

At times, it is desirable to operate two or more loudspeakers from the same output transformer. The question arises: For proper matching, (impedance of output transformers equal to combined impedance of speakers), what should the impedance of each loudspeaker be?

Assume that the radio worker knows that the output transformer secondary impedance is 8 ohms, and delivers 20 watts of power (maximum). He wishes to connect two speakers in parallel. (Fig. 3). The following expression solves our problem:

$R_s = nR_1$.

Where $R_s$ = impedance of each speaker to be connected, n = number of speakers to be connected, $R_1$ = impedance of output transformer secondary.

Substituting—

$R_s = nR_1 = 2 \times 8 = 16$ *ohms*

Therefore, to secure proper matching, each speaker is to have an impedance of 16 ohms. Since the output power of the transformer is 20 watts, the speakers should be rated at 10 watts apiece.

Where the speakers are of different impedances, the problem is more difficult, but equally solvable with the proper mathematics. RADIO-CRAFT covered the subject in an article "Matching Loudspeakers" December, 1944.

Mathematics can be considered as a tool or instrument in radio work, comparable to the ohmmeter and tube-tester in usefulness. It has two advantages over the serviceman's other instruments; it is less costly and not as bulky.

It should be noted that arithmetic was the only mathematics required for these problems. With algebra, trigonometry, and calculus at our command, our problem-solving abilities are increased many times. With this in mind, the following bibliography is given.

Cook, Nelson M., **Mathematics for Electricians and Radiomen.** New York: McGraw-Hill, 1942.

The book covers arithmetic, algebra, slide-rule, trigonometry, logarithms, a.c. circuits, vectors, etc. The exposition is very clear and the book has answers to problems. Highly recommended for beginners.

Hogben, Lancelot, **Mathematics for the Million.** New York: W. W. Norton & Co., 1937.

Mr. Hogben takes you through from mathematics of prehistory to calculus and statistics, against their social and cultural backgrounds. A "must" for the reader.

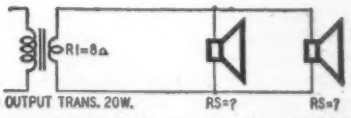



Fig. 3—Simple loudspeaker matching problem.

Jordan, Edward C. et al, **Fundamentals of Radio.** New York: Prentice Hall, 1942.

Chapter I contains a concise review of math, including logs and slide-rule.

Stranger, Ralph, **Mathematics of Wireless.** New York: Chemical Publishing Co., 1940.

The author gives the reader a "nibble" of algebra, trig, calculus, etc. Explanations are very lucid and concise.

By FRED SHUNAMAN

# NOMOGRAPH CONSTRUCTION

## *Part II—Charts with Complicating Factors or Constants*

THE difference between nomographic charts and ordinary graphs is that instead of having a fixed curve on paper cross-ruled in the quantities which enter a problem, *any* such curve can be selected by simply laying a ruler across the two lines which represent these quantities. This is why a nomogram, is "equal to an infinite number of charts." Obviously it is more useful than a fixed-curve graph in any problem in which it can be employed.

The simpler types of nomograms have already been dealt with, and the reader told how he can construct his own charts to cover any such problems. Somewhat more difficult constructions are often necessary, or may be found to give a better construction than the simple methods given in Part I.

In many nomograms, the figures which appear in the finished job are not the actual quantities being measured. This is to some extent true even in the multiplication chart, the simplest of nomograms. The two outside scales are evenly divided in logarithmic lengths, but we ignore them, and merely put down the numbers for which they stand.

We may wish, for example, to construct a nomogram showing the resistance of various kinds and sizes of wire. The formula is

$$R = kl/C.M.$$

k being the specific resistivity of the wire (varying for different metals), l the length in feet, and C.M. the area in *circular mils*. In this case, we calculate in circular mils but put down wire sizes in our finished chart. The specific resistivity and C.M. of all common metals and wire sizes are obtainable from tables available in many handbooks. It is necessary to construct a chart which will show the resistance for various areas, lengths and metals.

Our equation can be simplified by letting l (length) = 1. The chart will then read *resistance per foot*, and the equation will be

$$R = k/C.M.$$

This can be expressed in the form C.M. x R = k. C.M. and R. can then be the outside scales of a nomogram and k the center one. Laying out one of the outside lines with the C.M. areas of wire from size 30 to 40 (a 10 to 1 ratio) and the other in resistance values from 0.1 to 1.0 ohms per foot, the center line is calibrated with the help of a table of specific resistivity. Beginning with the lowest, silver (9.56) and copper (10.35) we go on to steel, approximately 100 (varying with the type of steel). The result appears in Fig. 5.

This chart is hardly satisfactory. Only half the middle scale is used. The range of wire sizes is very small. We cannot measure anything larger than No. 30. Important metals with high specific resistivity, such as nichrome and constantin, do not appear. Obviously it would be better to put the k scale outside, where it would cover twice its present length, and use the center scale for resistance in ohms. This can be done by changing our equation to R = k x 1/C.M. (A *reciprocal scale* like 1/C.M. can be made on a nomogram by simply turning the scale *upside down)* Now k and 1/C.M. can be the outside scales and R the middle one.

Since the resistivity of silver is slightly less than 10 and that of constantin near 300, our outside scales should have two cycles. This makes it possible for the C.M. scale to cover all wire sizes from 20 to 40 (most of the sizes commonly used in radio). The center scale will again have a range of four cycles.

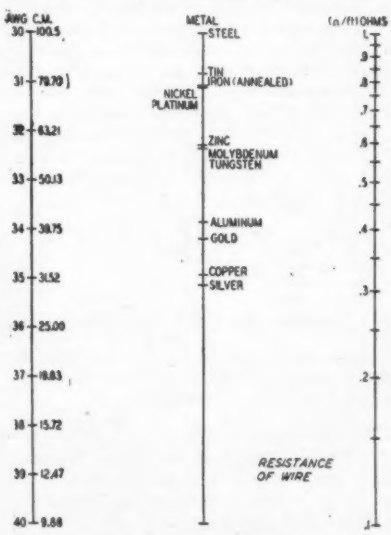



Fig 5—Crude chart showing wire resistance.

It is convenient to run *down* a column of wire sizes, so the C.M. scale is left as it is and the other two reversed.

Resistivity of silver is very slightly less than 10. Therefore the k scale can run from 10 to 1,000. Top of the center scale (Nomogram C) marks the resistance of a wire 1,000 C.M. in diameter and having a specific resistivity of 10. This resistance is .01 ohm. The base shows the resistance of a hypothetical wire with a resistivity of 1,000 and area of 10 circular mils. This is 100 ohms. Graduating this center scale in four cycles, from .01 to 100 ohms, the C.M. scale from 10 to 1,000, and spotting the k scale with the resistivity of the various metals in which we are interested, from silver at 9.56 (it is necessary to extend the scale slightly for this) to constantin at 296, we have a chart which will cover most of the sizes and materials used in radio work.

Numbers representing the wire sizes are now inserted on the C.M. scale and the circular mil figures (which are of no interest) are erased. Thus our nomogram, which started out with three sets of figures, ends up with only one, the other two scales being calibrated in wire sizes and names of metals.

If it is desired to extend the range to cover larger sizes of wire, the C.M. scale may be made into a double one. Readings may then be made from Nos. 1 to 40 (A.W.G. or B & S gage). If the figures on the R scale are read in ohms per hundred feet instead of ohms per foot, no change need be made in it. The completed graph is Nomogram C shown on page 700.

Still another type of nomogram is one in which one or more of the factors is multiplied by a constant, such as A x 4B = C. Since multiplication on a logarithmic scale is simple addition, we just start the B scale at 4. If the problem were A x B = 4C, the center scale would start at 4.

One of the best examples of this type of nomogram shows the inductance and capacitance required to tune to a given frequency. The formula is the well-known

$$f = \frac{1}{6.28\sqrt{LC}}.$$

The units are farads, henrys and cycles. To get the problem into microhenrys and microfarads—the practical units of radio—we can multiply numerator and denominator by 1,000,000, giving

$$f_{(cycles)} = \frac{1{,}000{,}000}{6.28\sqrt{L\mu h\ C\mu f}}$$

and by dividing the 6.28 into 1,000,000 we can further simplify it to

$$f = \frac{159{,}000}{\sqrt{L\mu h\ C\mu f}}.$$

*(Continued on page 701)*

# RADIO DATA SHEET 337

## EMERSON RADIO
## Models 501, 502, 504

### DESCRIPTION

**TYPE:** Single-band superheterodyne
**FREQUENCY RANGE:** 540-1620 kc.
**NUMBER OF TUBES:** Five
**TYPE OF TUBES:**

1—12SA7, pentagrid osc.-modulator
1—12SK7, first i.f. amplifier
1—12SQ7, diode detector, a.f. amp., a.v.c.
1—50L6GT, beam power output
1—35Z5GT, half-wave rectifier

**POWER SUPPLY:** a.c. or d.c.
**VOLTAGE RATING:** 105-125 volts
**POWER CONSUMPTION:** 30 watts

### ADJUSTMENTS

An oscillator with frequencies of 455, 600 and 1425 kc is required.

An output meter should be connected across the primary or secondary of the output transformer for observing maximum response.

Always use as weak a test signal as possible when aligning the receiver.

Plug the receiver into the power supply outlet in such a way that the ground side of the power line is connected to the receiver B —.

#### Coil and Trimmer Locations

The first i.f. transformer (T1) is mounted on top of the chassis deck to the right of the variable condenser. The trimmers (C5, C6) are accessible through holes in the top of the can.

The second i.f. transformer (T2) is mounted on top of the chassis between the variable condenser and the speaker. The trimmers (C7, C8) are accessible through holes in the top of the can.

The trimmer for the antenna (C3) and the trimmer for the oscillator coil (C4) are located on the variable condenser. The trimmer on the front section is for the oscillator coil.

The oscillator coil (T4) is located underneath the chassis. The loop antenna acts as the antenna coil.

#### I.F. ALIGNMENT

1. Rotate the variable condenser to the minimum capacity position.
2. Feed 455 kc to the converter grid (stator of the r.f. section of the variable condenser) and adjust the four i.f. trimmers (C5, C6, C7, C8) for maximum response.

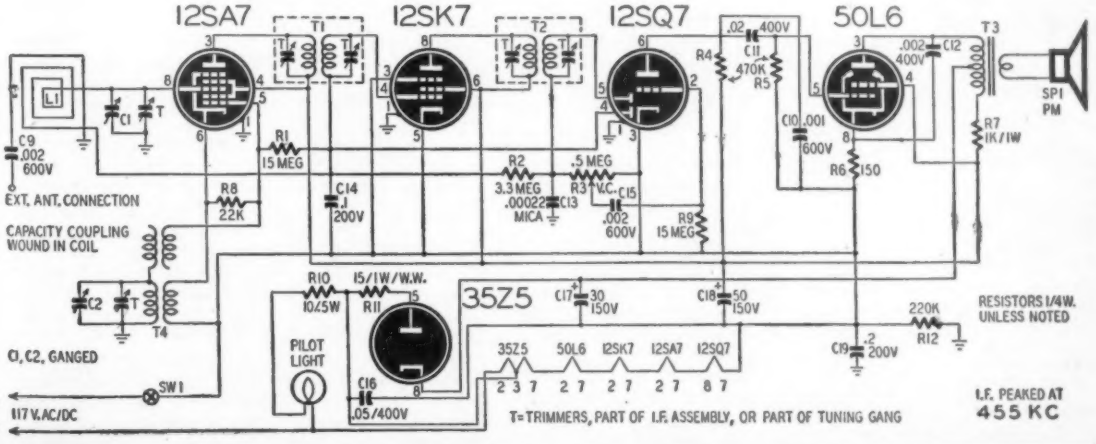
#### R.F. ALIGNMENT

1. Connect the oscillator to a coil composed of three to four turns of wire wound in a circle approximately 12 inches in diameter. This coil should be held parallel to and in line with the loop antenna of the receiver at a distance of 15 to 20 inches.
2. Radiate a signal at 1425 kc, set the dial indicator to 1425 kc, and adjust the trimmers on the variable condenser (C3, C4) for maximum response.
3. Radiate a 600 kc signal and tune in the signal on the receiver. Adjust the loose outside turn of the loop antenna for maximum response. This loose turn may be moved to either side of the center. Fasten it in the position which gives maximum response.
4. Repeat steps 2 and 3 until no further improvement is evident.

### VOLTAGES AT TUBE SOCKET PINS

The following voltage readings are d.c. measurements taken from B — (line switch) in the indicated tube-socket pin. A 1000 ohms-per-volt meter should be used for all readings except those indicated by an asterisk (*), which should be taken with a d.c. vacuum-tube voltmeter. Line voltage for these readings was 117 volts, 60 cycles, a.c. Measurements made with 117 volts d.c. will be lower than those given below. Take readings with the volume control set at minimum and the variable condenser closed (plates fully meshed).

| | PIN NUMBER | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TUBE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 12SA7 | | | 89 | 89 | *-10 | | | *-1.6 |
| 12SK7 | | | | *-1.6 | | 89 | | 89 |
| 12SQ7 | | *-0.7 | | *-1.6 | -0.5 | 37.5 | | |
| 50L6GT | | | 110 | 89 | | | | 6.2 |
| 35Z5GT | | | | 116 | | 116 | | 117 |



By JORDAN McQUAY

# CATHODE FOLLOWERS

## *Find Many Applications in the Most Modern Apparatus*

IMPEDANCE matching is of great importance in radar, television, and most industrial electronic circuits—primarily to prevent unnecessary distortion of complex wave forms. High-impedance outputs of video amplifiers must feed transmission lines or other low-impedance devices *without* phase shift, polarity change, or distortion of the video signal. Ordinary transformers are useless for this purpose, because of the wide range of frequencies involved—from 30 cycles up to 4 or 5 megacycles. One of the most satisfactory impedance matching devices is the *cathode follower*.

Sometimes known as a cathode-loaded amplifier, it is not an amplifying stage since it provides less than unity voltage gain.

A cathode follower is a degenerative vacuum-tube circuit in which inverse feedback is obtained via an *un*bypassed cathode resistor. The load of the tube is adjacent to the *cathode* instead of to the plate. Input signals can be applied between ground and the control grid of a triode or pentode. Output is taken from across the cathode resistance or from across a cathode and a plate resistance (inverters).

Being degenerative, the circuit has a lower input capacitance, is much freer from amplitude and phase distortion, and is less affected in its operation by variations in supply voltage and tube aging than a conventional amplifier stage.

A cathode follower is inherently a distortionless impedance-matching or impedance-changing device, providing a low-capacity high-impedance input with a well-regulated low-impedance output *in phase with* the input signal.

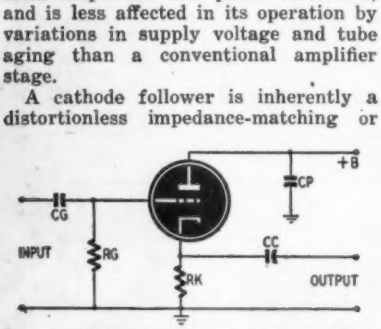


Fig. 1—The basic cathode follower circuit.

### THE BASIC CIRCUIT

Basic type of cathode follower is shown in Fig. 1. The stage employs a triode, and is frequently encountered in radar and certain other electronic applications.

Input circuit elements consist of a grid coupling condenser $C_G$ and a grid resistor $R_G$. Plate condenser $C_P$ bypasses any apparent or reflected resistance. Voltage to the plate of the triode is maintained constant. Normally there is *no* load resistor at the plate in a cathode follower.

Resistor $R_K$ is the all-important cathode load resistor. It is *not* by-passed by a condenser. All of the output voltage of the stage (Fig. 1) is developed across the cathode resistor $R_K$.

However, all of the output voltage *also* appears in the grid-to-cathode circuit. This results in a 100-percent voltage feedback opposing the input signal voltage. Thus, the net voltage gain of the stage is less than unity. And there is a reduction in the effective a.c. plate resistance of the triode.

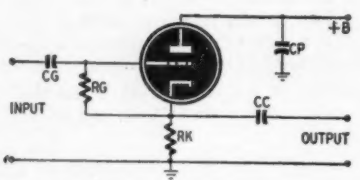


Fig. 2—Modification for large minus voltages.

During positive portions of the input signal, any rise in plate current through the cathode resistor $R_K$ produces a greater *IR drop*, which makes the cathode of the triode more positive. During negative portions of the input signal there is a reverse result: a decrease in plate current causes the cathode to become less positive.

Thus the voltage across the cathode resistor (Fig. 1) follows all fluctuations of the grid, which in effect tends to reduce the voltage difference between grid and cathode.

When no signal is applied to the grid of the triode (Fig. 1) the normal small amount of no-signal plate current flows through the cathode resistor. The resulting *IR drop* establishes the amount of no-signal bias developed across resistor $R_K$.

Changes in the input voltage must appear in part as changes in grid bias. This changed grid bias is available as the output voltage of the cathode follower.

Since changes in plate current resulting from an input signal on the grid causes a voltage change across $R_K$ *in the same direction* as the applied signal, no polarity inversion results. A positive-going input wave produces a positive-going output wave, and a negative input produces a negative output.

Degeneration reduces the effective input voltage below the applied value, causing less current to flow through the capacities within the triode. Because of the high and constant input impedance, the cathode follower has a negligible loading effect on the circuit employed to drive it (if no grid current is permitted).

Output impedance of the circuit (Fig. 1) is the parallel combination of the cathode resistor $R_K$ and the effective a.c. plate resistance of the tube. Since both of these can be made relatively low in value, the output impedance of a cathode follower can be made extremely low—often as small as 30 or 40 ohms, when required. Value of the output impedance can, of course, be chosen to match the input impedance of the following stage, device, or transmission line.

### LIMITING EFFECTS

Output voltage of the basic circuit (Fig. 1) is a direct function of the input signal over its normal range of operation—determined by the nature of the tube's characteristic curve.

Within this normal range of operation, the output voltage is a duplicate of the input voltage and is essentially without distortion. When *positive* portions of the input exceed the normal range, the cathode follower continues to operate in the same manner (up to the point of grid current). Because of degeneration the grid current point is not reached as soon as in a conventional amplifier.

However, when *negative* portions of the input exceed the normal range of operation, the region of plate-current cut-off is soon reached. Any further grid voltage increase in a negative direction does *not* appear in the output wave form. This is a form of limiting or clipping.

Thus the circuit of Fig. 1 provides a distortionless output only for input voltages within the normal range of operation and for large *positive* input voltages (up to grid current point). For larger *negative* input signals, the cathode follower (Fig. 1) introduces serious distortion.

In many applications of a cathode follower where negative input voltages are never large, this disadvantage is not important, and the circuit shown in Fig. 1 will be adequate.

### TRIODE VARIATIONS

In those instances where a cathode follower must reproduce large *negative* input voltages and some distortion of *positive* input voltages can be tolerated, the circuit shown in Fig. 2 is employed.

*(Continued on page 725)*

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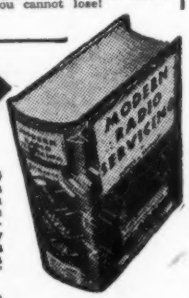


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Edited by ELMER R. FULLER

# WORLD-WIDE STATION LIST

WITH the coming of the summer season, we can look forward to the dx to be found on the higher frequencies. The nineteen meter band is very active at this time of the year, and some fine business results should be forthcoming. Also, note should be made of 16 meter broadcast band for day and night dx, which is generally wide open at this time of year.

HCJB at Quito, Ecuador, is a very good bet on 15.110 megacycles during the early summer evenings. Reports on this and the other frequencies used by HCJB may be sent to them at Quito, Ecuador; and a very good verification will be sent to the reporter. VUD3 in Delhi, India, should be a good catch during July and August. The frequency used is 15.290 megacycles and is heard best around 6 to 7 am.

The Australians are good on the high frequencies now, and are usually heard best on 15.315 megacycles. Their transmissions are beamed to North America at 9:15 to 9:45 pm; but they are often heard at other times when beamed to other localities. Reports may be sent to the Australian News Agency, 630 Fifth Avenue, New York City.

Brazzaville is heard on 17.527 megacycles in the early morning shortly after midnight. Reception is very good in summer on this frequency; as are the other Brazzaville transmissions. Several BBC transmissions may be heard on the 19 and 16 meter bands. Also the BBC may be heard on their 11 meter transmission on 26.100 megacycles.

## RADIO TERM ILLUSTRATED

*Suggested by: James Tannehill, Ft. Wayne, Ind.*

**Dynamic Speaker.**

VUD10 from Delhi, India, is being heard on 17.830 megacycles from 10:15 pm to 2:30 am; and 4 to 7 am. Other Delhi transmitters are on 17.760 mc from midnight to 5 am; and 15.290 mc from 10:45 pm to 12:30 am; 1 to 5 am; and 6 to 7 am. A Moscow station is heard to North America at 7:15 to 8:15 am on 17.810. This is a new transmission on this frequency.

ZAA in Tirana, Albania, is being heard on 7.295 megacycles at 1:30 pm. Reception reports so far are fair, and a good signal now and then. They are worth trying for though. A new station on Borneo is at Balikpapan and is heard with strong signals on 9.125 megacycles from 7 to 9:30 am. English announcements are made at 8 am.

Our chart this month gives the complete shortwave schedule of the British Broadcasting Co., the biggest English-speaking broadcast organization outside the United States. The schedules are divided into North American broadcasts and others; but many North American listeners will note little difference between certain beams intended for them and some beamed to other countries.

This is all till next month, when we will be back with more news for you. So get your reports in. Remember all times given above are E.S.T. Reports may be sent to Elmer R. Fuller, Shortwave Editor, c/o RADIO-CRAFT, 25 West Broadway, New York City. Reports from overseas will be greatly appreciated.

| Freq. | M | 1 a.m. | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | N | 1 p.m. | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Mid. | Call |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.070 | | | | | | | | | | | | | | | | | | | | | | | | | | GRR |
| 6.110 | | | | | | | | | | | | | | | | | | | | | | | | | | GSL |
| 7.075 | | | | | | | | | | | | | | | | | | | | | | | | | | GRS |
| 7.120 | | | | | | | | | | | | | | | | | | | | | | | | | | GRM |
| 7.230 | | | | | | | | | | | | | | | | | | | | | | | | | | GSW |
| 7.260 | | | | | | | | | | | | | | | | | | | | | | | | | | GSU |
| 7.320 | | | | | | | | | | | | | | | | | | | | | | | | | | GRJ |
| 9.510 | | | | | | | | | | | | | | | | | | | | | | | | | | GSB |
| 9.580 | | | | | | | | | | | | | | | | | | | | | | | | | | GSC |
| 9.600 | | | | | | | | | | | | | | | | | | | | | | | | | | GRY |
| 9.625 | | | | | | | | | | | | | | | | | | | | | | | | | | GWO |
| 9.640 | | | | | | | | | | | | | | | | | | | | | | | | | | GVZ |
| 9.660 | | | | | | | | | | | | | | | | | | | | | | | | | | GWP |
| 9.825 | | | | | | | | | | | | | | | | | | | | | | | | | | GRH |
| 9.915 | | | | | | | | | | | | | | | | | | | | | | | | | | GRU |
| 11.140 | | | | | | | | | | | | | | | | | | | | | | | | | | GSN |
| 11.680 | | | | | | | | | | | | | | | | | | | | | | | | | | GRG |
| 11.700 | | | | | | | | | | | | | | | | | | | | | | | | | | GVW |
| 11.750 | | | | | | | | | | | | | | | | | | | | | | | | | | GSD |
| 11.820 | | | | | | | | | | | | | | | | | | | | | | | | | | GSN |
| 11.930 | | | | | | | | | | | | | | | | | | | | | | | | | | GVX |
| 12.095 | | | | | | | | | | | | | | | | | | | | | | | | | | GRF |
| 15.110 | | | | | | | | | | | | | | | | | | | | | | | | | | GWB |
| 15.140 | | | | | | | | | | | | | | | | | | | | | | | | | | GSF |
| 15.180 | | | | | | | | | | | | | | | | | | | | | | | | | | GSO |
| 15.260 | | | | | | | | | | | | | | | | | | | | | | | | | | GSI |
| 15.300 | | | | | | | | | | | | | | | | | | | | | | | | | | GWR |
| 15.310 | | | | | | | | | | | | | | | | | | | | | | | | | | GSP |
| 15.450 | | | | | | | | | | | | | | | | | | | | | | | | | | GRD |
| 17.760 | | | | | | | | | | | | | | | | | | | | | | | | | | GVP |
| 17.715 | | | | | | | | | | | | | | | | | | | | | | | | | | GRA |
| 17.730 | | | | | | | | | | | | | | | | | | | | | | | | | | GVO |
| 17.790 | | | | | | | | | | | | | | | | | | | | | | | | | | GSG |
| 17.810 | | | | | | | | | | | | | | | | | | | | | | | | | | GSV |
| 17.870 | | | | | | | | | | | | | | | | | | | | | | | | | | GRF |
| 18.025 | | | | | | | | | | | | | | | | | | | | | | | | | | GRQ |
| 18.080 | | | | | | | | | | | | | | | | | | | | | | | | | | GVD |
| 21.470 | | | | | | | | | | | | | | | | | | | | | | | | | | GSH |
| 21.530 | | | | | | | | | | | | | | | | | | | | | | | | | | GSJ |
| 21.640 | | | | | | | | | | | | | | | | | | | | | | | | | | GRZ |
| 21.710 | | | | | | | | | | | | | | | | | | | | | | | | | | GVS |

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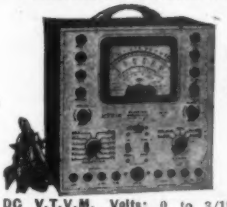

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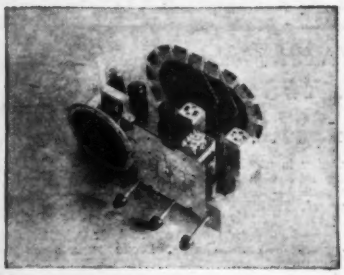

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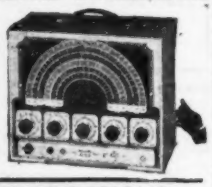

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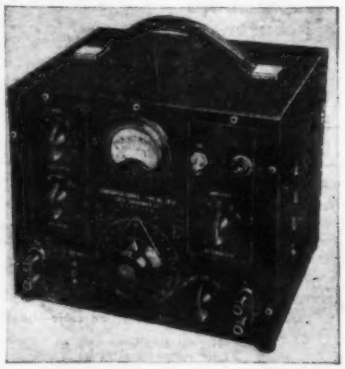
The circuit uses an oscillator, bridge and high-gain amplifier. Null indications are amplified and read on a 500-microampere meter. Condensers from 500 μμf to 10 μf are measured at 1000 cycles; larger ones at 60 cycles. Condensers smaller than 500 μμf are measured by the limit bridge method. Resistors from 10 ohms to 1 megohm are measured by the comparison method; higher values by using the instrument as a limit bridge. Inductances from 0.1 millihenry to 100 henries are measured at frequencies determined by their characteristics.

All measurements are made with .5 percent accuracy when using the 10



percent range. Maximum voltage across the UNKNOWN terminals is 15.

The instrument uses five tubes and is rated at 40 watts, 105 to 125 volts, 60 cycles a.c.—RADIO-CRAFT

## AUDIO FREQUENCY METER

Communication Measurements Laboratory
New York, N. Y.

The Model 1800 frequency meter is designed for measuring the frequency of a.c. voltages over the entire audio frequency spectrum. When used with special attachments, it may be used as a tachometer. It is capable of measuring frequencies from 60 to one million

RPM or CPM with equal ease and accuracy.

Operation of the device is independent of input waveform and may be used to measure pulse voltages having a duration of 50 to 100,000 microseconds. It may be used in applications where a highly accurate audio frequency meter is desirable.

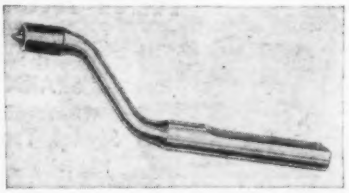
Vibration rates may be measured by the application of a suitable pickup to any stationary object subject to vibration.—RADIO-CRAFT

## DIAMOND PHONO NEEDLE

The Duotone Co., Inc.
New York, N. Y.

The world's most expensive phonograph needles for home use are now on the market. They are diamond-point needles costing fifty dollars each.

By using professional diamond pol-

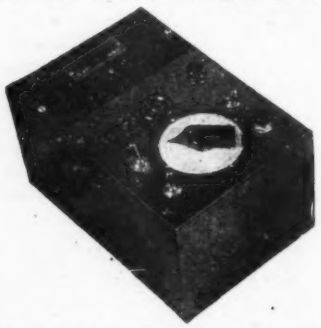


ishers, the needle tip radius has been held to a tolerance of one ten-thousandth of an inch. This needle has been under test for five years and during this time there has been no indication of wear on the tip.—RADIO-CRAFT

## ELECTRONIC TIMER

Photovolt Corp.
New York, N. Y.

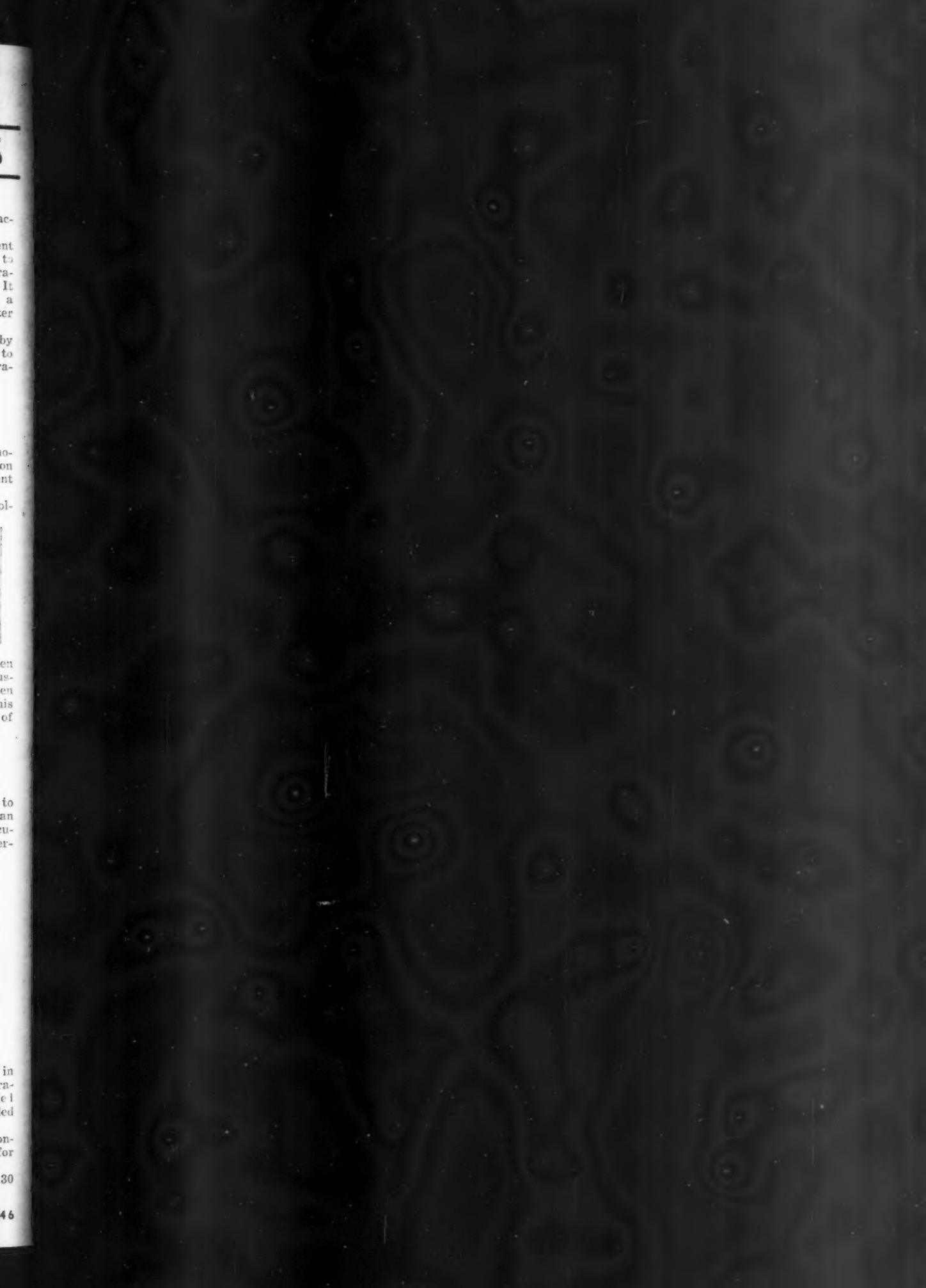
This electronic timer is designed to open or close electrical circuits for an adjustable time interval. It is particularly applicable for timing short inter-



vals from .05 second to 50 seconds, in five models, each with a 10-1 time ratio. A load outlet receptacle is provided for coupling the timer to the controlled circuit.

Two or more timers may be connected for operation in sequence or for re-cycling action.

The timer is operated from 100 to 130 volts a.c. or d.c. lines.—RADIO-CRAFT



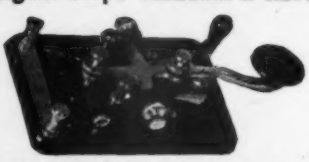
# CALRAD "Hard-to-get" RADIO VALUES!

## V.M. TWO POST AUTOMATIC RECORD CHANGER

This Record Changer is a well-made mechanism, will play either 10-in. or 12-in. records. The pickup uses a crystal cartridge. Size 14 in. x 14 in. Packed 2 to a factory-sealed carton, factory guaranteed.

CARTON OF 2 **$35.00 Special $18.95 ea.**

## Signal Corps TELEGRAPH KEYS



Genuine U.S. Signal Corps telegraph keys brought to you at prices below manufacturing costs! Made with switch to close contacts, polished durable enameled metal base mounted on a bakelite base; key lever is nickel-plated; contacts are brass-silver. Packed in new original boxes.

LOTS OF 10 **75c ea** CARTON OF 50 **60c ea**

## 5 Tube Super AC-DC PARTS KIT

Kits include: Stamped Chassis-Dynamic Speakers—Output Transformer—Volume Control and Switch—2 Shielded I.F. Coils—Antenna and Osc. Coils—Two-gang Super Variable—50 Octal Sockets—20 x 20 Mfd. 150 Volt Filter—5 Tubular Condensers—3 Mica Condensers—6 Resistors—6 ft. AC Cord and Plug—Circuit Diagram.

While They Last **$8.95 ea.** Lots of 6 **$50.00**

## AUTO ANTENNAS

- 3 Section
- 66" Long
- Brass Tubing
- Triple Chromium Plated
- 2 Insulator Type Cowl

Mounting with Lead Individually Boxed

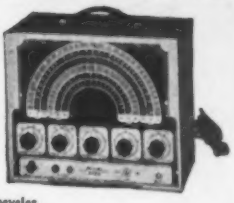
24 TO MASTER CARTON **$30.00**

LOTS OF 48 **$55**

Immediate Delivery But Quantity Is Limited

## Approved SIGNAL GENERATOR

Model A-100 Complete **$47.00**



A-100 to 310 Kilocycles
B-320 to 1000 Kilocycles
C-1000 to 3200 Kilocycles
D-3.2 to 10.5 Megacycles
E-10.5 to 26 Megacycles
E2-21 to 52 Megacycles

440 Standard Audio Frequency (same as WWV) Internal modulation at 440 cycles (same as WWV). External modulation possible from 40 to 30,000 cycles.

## WEBSTER RECORD CHANGER

Model 56 Complete **$26.45 each**

Built to last. Fast change cycle. Simple, foolproof operation. Automatic shut-off. Feather light needle pressure. Longer life for records. Quiet running Webster 4 Pole motor-cushion mounted.

**Webster Model 50. . ea. $20.95**

## BUY NOW! LOWEST PRICES! STOCKS LIMITED!

**Fully Shielded Power Transformers**
50 Mill—6.3 Vo. @ 2 amp. C.T.—5 Vo. @ 2 amp. C.T.—650 Vo. C.T. $2.45 ea. Lots of 10—$2.25 ea.

**Push Pull 6L6 Shielded Output Transformer**
30 Watt Peak, to 2-4-6-8-16-250 and 500 ohm line. $3.45 ea. Lots of 12, $3.25 ea.

**Push Pull Input Transformer, 10,000 ohm plate to push pull 6L6—$1.10 ea. Lots of 12—$1.00 ea.**

**Midget Universal Output Transformer—push pull plate to 2-4-6-8-10-16 ohm voice coil—85c ea. Lots of 10—85c ea.**

**10 Watt Large Universal Output—$1.35 ea. Lots of 10—$1.20 ea.**

**Single Pentode Midget Output—for 50L6, 6V6, 6F6, etc.—55c ea.**

**50 Mill Filter Choke 300 ohm—65c ea. Lots of 10—60c ea.**

**75 Mill Filter Choke 250 ohm—85c ea. Lots of 10—85c ea.**

### DYNAMIC AND P.M. SPEAKERS

**4-In. 450-Ohm Dynamic—Packed 30 to Carton—$1.75 ea.**

**4-In. 2500-Ohm Dynamic—Packed 30 to Carton $1.75 ea.**

**4-In. P.M. Heavy Slug—Packed 30 to Carton—$1.70 ea.**

**5-In. P.M. Heavy Slug—Packed 30 to Carton—$1.75 ea.**

**6-In. P.M. Heavy Slug—Packed 30 to Carton—$2.25 ea.**

### TUBULAR ELECTROLYTIC CONDENSERS

10 Mfd. 50 Volt—Lots of 25—21c ea.
25 Mfd. 50 Volt—Lots of 25—24c ea.
50 Mfd. 50 Volt—Lots of 25—28c ea.
16 Mfd. 150 Volt—Lots of 25—25c ea.
20 Mfd. 150 Volt—Lots of 25—29c ea.
30 Mfd. 150 Volt—Lots of 25—32c ea.
50 Mfd. 150 Volt—Lots of 25—35c ea.
20 x 20 Mfd. 150 Volt—Lots of 25—43c ea.
30 x 20 Mfd. 150 Volt—Lots of 25—47c ea.
40 x 20 Mfd. 150 Volt—Lots of 25—55c ea.
50 x 30 Mfd. 150 Volt—Lots of 25—65c ea.
20 Mfd.—350 Volt—Lots of 25—39c ea.
10 Mfd.—300 Volt—Lots of 25—39c ea.
20 Mfd.—25 Volt—Lots of 25—39c ea.

### Standard Brands, Tubular By-Pass Condensers

.001-.002-.003-.005-.006-600 Volt ....$6.75 per 100
.025-.01-.02-600 Volt .....$7.75 per 100
.05-600 Volt .....$9.75 per 100
.1-600 Volt .....$12.00 per 100
.25-600 Volt .....$18.00 per 100
.5-600 Volt .....$22.00 per 100
4 Mfd. 600 Vo. T.L.A. Oil Condenser, screw base. Upright aluminum can, 1½ in. x 3¾ in. ....$4.50 list, replaces 8 mfd. 600 Vo. electrolytic. Carton of 40 .....$38.50

### FINEST QUALITY MIDGET MICAS:

.001-.0001 .005-.00005 .002-.00025 .006-.0005 } $5.00 per 100

**Astatic Low Pressure, curved arm, crystal pickup with Sapphire Stylus Permanent Needle, has cartridge which replaces LP6-LP21-LP23. $3.75 ea; Lots of 10—$33.50**

**Standard Low Pressure Crystal Pickup. $2.50 ea; Lots of 10—$22.50**

**Signal Corps Dual Headsets—8000 ohms high impedance, with 2 rubber ear cushions, cord and phone plug, individually boxed, $12.50 list, net $2.25 ea., lots of 12, $25.**

**456 K.C. Antenna, Oscillator and R.F. Coils, 25c ea.**

**456 K.C. I.F. Coils Input & Output, medium size can .....$45.00 per 100 asst.**

**Weston Volt ohm meter Model 663—$49.50 with carrying case & leads.**

**Universal 4-Prong Electronic Vibrator....$1.75 ea. 6-Prong Synchronous Mallory Vibrator....$1.75 ea.**

**Kit of 50 assorted Bakelite Knobs for ¼-in. shaft, with set screws .....$2.50 per kit**

**Midget Ceramic Trimmers—3-30 mmf., $6.00 per 100**

**Western Electric—0-200 Microammeter—3 in bakelite case, $4.25 ea.**

**Tinned Copper Shielding—⅛ in., ¼ in., ⅜ in. $1.50 per 100 ft.**

**Rubber Sheathed "Mike" Cable, shielded, single Conductor 100 ft. for $ 5.95 500 ft. for $25.00**

**Moulded Loctal Sockets 1½-in. mtg. with metal ring $7.00 per 100**

**6 ft. A.C. Cords with plug .....$20.00 per 100**

**Volume Controls, less Switch—1½-in. shaft 250,000 ohm. 1 Meg Lots of 100 2 Meg $30.00**

**250 ft. Coil Underwriter Approved Zip Cord—$4.75 per coil.**

**Turner Juke Box Type Crystal Microphone with 100 ft. shielded mike cable—$9.95 ea.**

**Transmitting type variable Condensers, Dual Double Spaced 110 Mfd. per sect'on $1.00 ea.**

**Dual Double Spaced 170 Mfd. per section $1.00 ea.**

**Single Gang Dual Spaced 440 Mfd.—$1.00 ea.**

**Single Bearing Midget Condenser 14 plate—100 Mfd. 50c ea.**

**Midget Open Circuit Jack—Lots of 10—$1.50**
**Midget Closed Circuit Jack—Lots of 10—$2.00**
**Midget Double Circuit Jack—Lots of 10—$2.00**

### SIGNAL CORPS JACKS

**Signal Corps Jacks, fits all standard plugs. Open circuit, Mallory type SC-1 equivalent of Signal Corps Jack #JK 34A.....$12.00 per 100 $100.00 per 1000**

**Insulated Banana Tip Jacks, red or black $8.50 per 100**

**Insulated Banana Plugs, solderless, side screw connection, red or black.....$10.00 per 100**

**Standard Barrel Type Phone Plug...$20.00 per 100**

**Sterling #44 Pocket Volt-Amp meter with carrying case—$1.00 ea.**

**Patch Cord 4 ft. with 2 P.L. 55 Plugs—49c ea.**

**MAIL ORDERS FILLED:** P.O. Money Order, Express or C.O.D. Business Hours 8 A.M. to 5 P.M. Santa Monica & Vermont Avenues Los Angeles, California

## CALIFORNIA RADIO & ELECTRONICS CO.

Dept. No. R, 711 No. Vermont Ave., Los Angeles 27, California

*The Victrola*, made exclusively by RCA Victor, gives higher fidelity and longer record life through its jewel-point pickup.*

## *Your Victrola's jewel-point pickup floats like a feather on water—*

Instead of an ordinary, rigidly mounted needle, your Victrola radio-phonograph has a moving sapphire playing tip that fairly floats over the record.

It follows the groove with effortless ease, achieves new clarity of tone, adds longer life to records, and acts as a filter against surface noise.

Such a feather touch reduces "needle chatter," gives you all the rich warm flow of the pure music . . . the highest tones, the lowest tones, the overtones. Truly, your Victrola's jewel-point pickup brings you the ultimate in recorded music pleasure.

This pickup was perfected at RCA Laboratories—a world center of radio and electronic research—where RCA products are kept at the top of the field.

And when you buy an RCA Victor radio, television receiver, Victrola, or even an RCA radio tube replacement, RCA Laboratories is your assurance that you are getting one of the finest products of its kind that science has yet achieved.

• • •

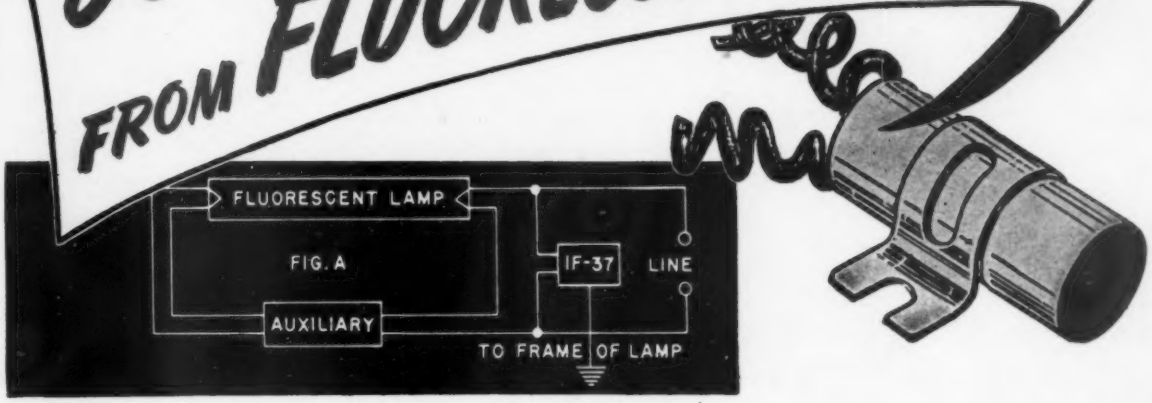
*Radio Corporation of America, RCA Building, Radio City, New York 20 . . . Listen to The RCA Victor Show, Sundays, 4:30 P. M., Eastern Daylight Time, over the NBC Network.*

**New Victrola radio-phonograph,** with Chippendale-style cabinet, priced at approximately $275. "Rollout" record changer handling twelve 10-inch, or ten 12-inch records. Permanent jewel-point pickup—no needles. American and foreign radio reception. An outstanding radio-phonograph combination—thanks to research at RCA Laboratories.

*Victrola T. M. Reg. U. S. Pat. Off.

**RADIO CORPORATION of AMERICA**

# SUPPRESS RADIO NOISES FROM FLUORESCENT LAMPS!




## EASILY INSTALLED — HIGHLY EFFECTIVE

The most serious radio interference from fluorescent lamps is that which is conducted down the power line to receivers at remote points. Such interference cannot be avoided merely by placing the lamp at a safe distance from the radio antenna circuit. Nor can it be avoided by using shielded lead-in wire, as in cases where interference is caused, either by direct radiation from the lamp bulb itself or by radiation to the radio antenna circuit from the electric supply lines.

Yet interference conducted down the power line to remote receivers should, and CAN, be reduced.

The really effective method is to connect Sprague IF-37 Filters directly to each fixture as indicated in the above diagram. These filters are specifically designed for fluorescent lamp interference suppression. They are recommended for single lamp fixtures, connected as shown in figure "A". One filter is required for each auxiliary.

Type IF-37 Filters are EASY to install. Inexpensive, too—only $1.11 each, net.

### RADIO DEALERS! REMOVE INTERFERENCE IN YOUR OWN STORE

The use of Type IF-37 Filters in your own store will help you sell more radios through better demonstration. Your sets may be perfect, but if your own fluorescent lamps interfere with reception your customers may assume the radio is at fault.

*Don't let noise spoil your sales!*

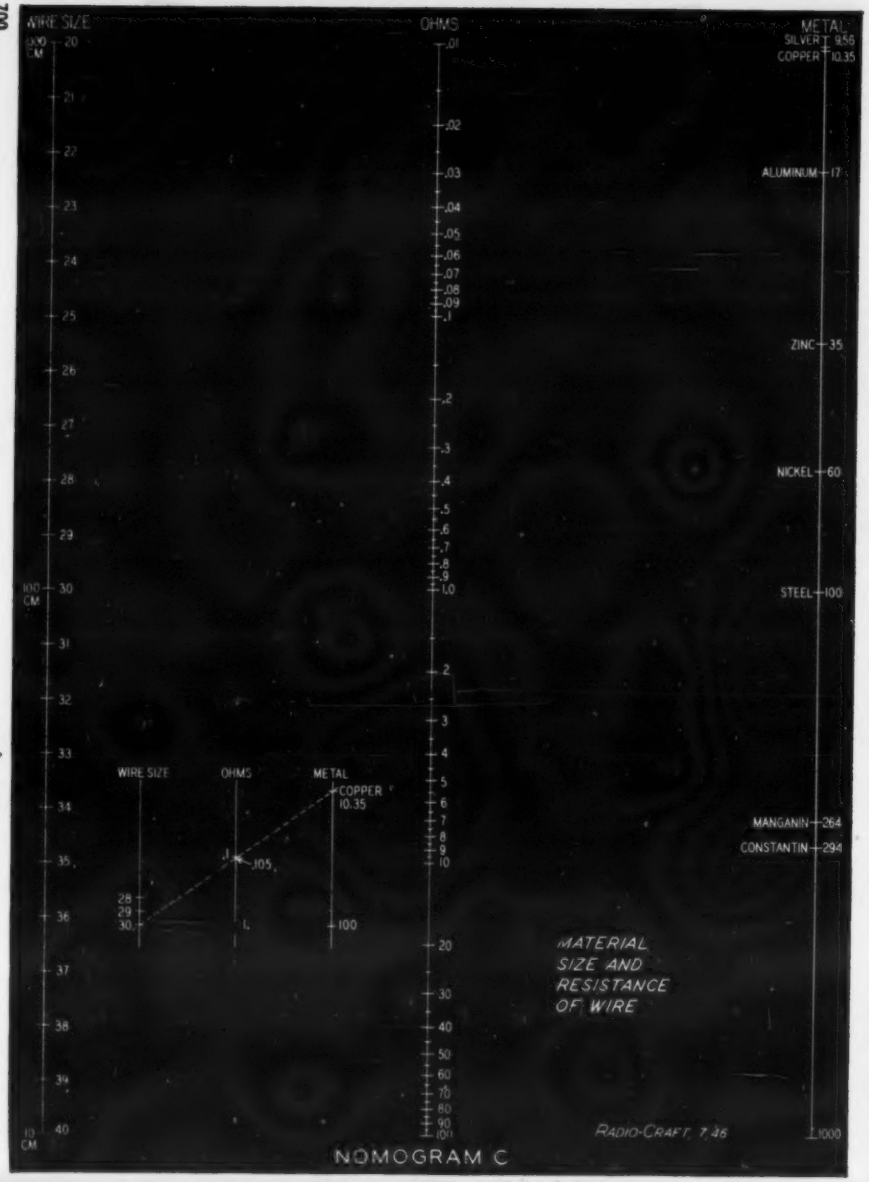
**WRITE**

for your copy of the new Sprague Catalog No. C-306. It's the first Sprague Catalog in five years devoted to civilian radio service. In it you'll find new capacitor types and outstanding resistor improvements. Write for your new catalog today!

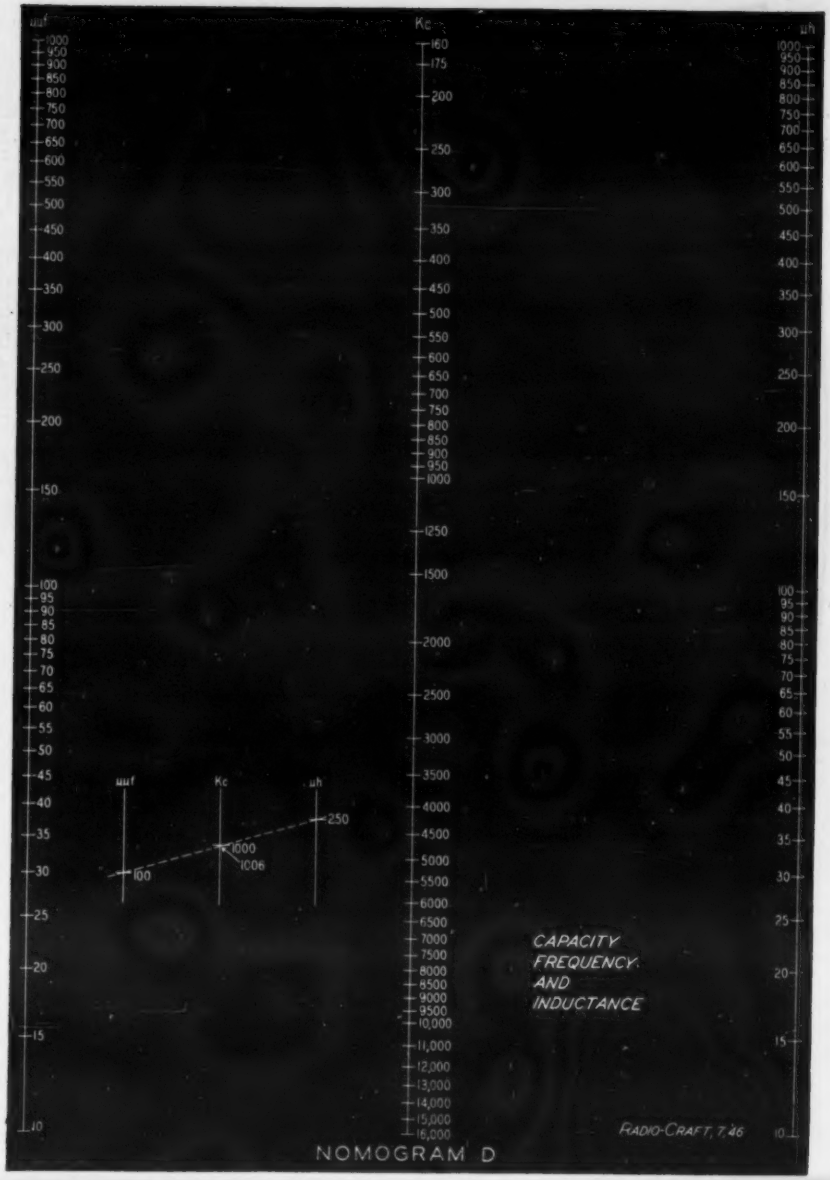
# SPRAGUE PRODUCTS CO.

NORTH ADAMS, MASS.

Jobbing Distributing Organization for Products of the Sprague Electric Co.




NOMOGRAM C




NOMOGRAM D

NOMOGRAM C
NOMOGRAM D

## NOMOGRAPH CONSTRUCTION

*(Continued from page 690)*

The frequency in cycles is then equal to 159,000 times

$$\frac{1}{\sqrt{LC}}$$

in microhenrys and microfarads.

On the nomogram, inductance and capacitance run in opposite direction to the frequency scale, since the greater the product of the two, the smaller is the number of cycles per second. The "product" scale will differ from those previously drawn. Though it is in the center, it will have the same number of cycles as the "factor" scales. This is because we are using the square roots of the factors. (If Fig. 2, in the June issue, were to represent the product of the square roots of numbers from 1 to 10 it would be necessary only to number the three scales identically.) Then a line drawn through any two numbers on the outside scales would show on the center one the product of their square roots. (A line through 9 and 4 would cut the center line at 6, the product of their square roots, 3 and 2.)

For most work where lumped constants are used, it is seldom necessary to calculate circuits with inductances of less than 10 microhenrys or capacities less than 10 μμf. Using two-cycle paper with these quantities for a base for the two outside scales, we have a top of 1,000 microhenrys or micromicrofarads. (See Nomogram D, on opposite page.)

It is a simple matter to calculate calibration points on the center scale by our equation,

$$f = \frac{159{,}000}{\sqrt{L\mu h\ C\mu f}}.$$

10 μh and 10 μμf (.00001 uf) are the bases of the two outside scales. 10 μh × .00001 μf = .0001. The square root of this is .01, which divided into 159,000 gives us 15,900,000 cycles, or 15,900 kc. Making the same calculations at the 100 points (100 μh × .0001 μf) and at the top of the scale give us 1,590 kc and 159 kc respectively. From these we can obtain—with the help of 2-cycle paper—a complete calibration from 169 to 15,000 kc. Thus the finished chart (Nomogram D) will serve for practically all i.f., standard broadcasting and international shortwave broadcasting frequencies.

By clipping the top of our scales at 500 kc and increasing them proportionately at the bottom, the nomogram could be made to cover all frequencies from the broadcast band to 50 megacycles. This is done by starting out with three-cycle paper, then cutting the finished chart down to whatever size is necessary for mounting, publication or other purposes.

More complex charts may be constructed. A common one has four elements ( A × B × C = D.) The straight

*(Continued on page 719)*

TURNER
Model 33

meets every requirement
for a RUGGED
ALL-PURPOSE MICROPHONE

Packed with power to spare — built to take rough handling and bad climate conditions — engineered for smooth response to both music and voice pickups, the Turner Model 33 is an all-around microphone for recording, P.A., call system, studio, and amateur work. A professional unit for professional results. Ask your distributor or write.

*Free Turner Catalog*
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THE TURNER COMPANY
902 17th Street, N.E.
Cedar Rapids, Iowa

*LOOK at these Performance Features*

**33X Crystal**

- Moisture-sealed crystal.
- 90° tilting head.
- Wind and blast-proofed.
- Barometric compensator.
- Chrome finished case.
- Level -52DB.
- Range 30-10,000 cycles.
- Removable cable set.

**33D Dynamic**

- Heavy duty dynamic cartridge.
- 90° tilting head.
- Wind and blast-proofed.
- Chrome finished case.
- Level -54DB.
- Range 40-10,000 cycles.
- Removable cable set.
- Choice of impedances.

Licensed under U.S. Patents of the American Telephone & Telegraph Company, and Western Electric Company, Incorporated.
Crystals licensed under patents of the Brush Development Company

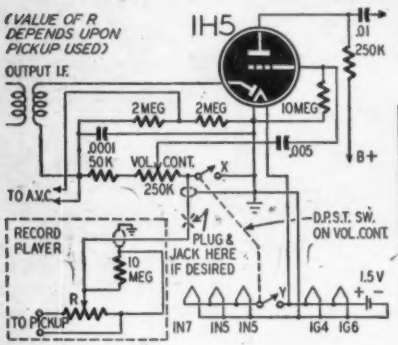
TURNER Microphones

# RADIO·ELECTRONIC CIRCUITS

## BATTERY RECORD PLAYER

I was able to convert my battery-powered radio into a portable record player with minor changes in the existing circuit.

No changes were made in the circuit except to open it at points X and Y. The




arms of a d.p.s.t. switch are inserted at these points. This switch is a Mallory No. 7, or equivalent, attachable to the volume control. By turning the volume control to the extreme left position the filament voltage of the r.f. section of the receiver is removed, and the set functions as an audio amplifier, saving battery power.

Normal radio action is restored by turning the volume control to the right, permitting the filament voltage to reach the r.f. stages and grounding one end of the volume control. The delay due to r.f. tube filament heating is negligible.

J. W. TWILLEY
*Manitoba, Canada*

(Presumably Mr. Twilley inserted the phono pickup at the ground end of the 250,000 ohm volume control to prevent capacitive effects when the radio is being used. If the record player is not equipped with its own volume control, the phono input may be made to the other end of the receiver volume control and switch X omitted. The receiver volume control is then operative on radio or phonograph.—*Editor)*

## A NEAT PHONO AMPLIFIER

Here is the circuit of a neat phono amplifier that can be constructed easily with parts salvaged from an old broadcast receiver using 2.5-volt tubes. (Lower left corner.)

The input stage uses a 57-tube resistance coupled to a 56 driver. The driver is transformer coupled to the push-pull 45 output tubes.

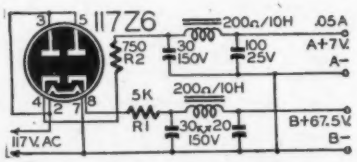
Self-bias for the 45's is obtained by inserting a 750-ohm wire-wound resistor between the center-tap of the filament winding and ground. The hum level is kept low by a grounded center-tapped resistor (hum-dinger) across the 56 and 57 heaters.

JOSEPH SWARTZ,
*Toronto, Canada*

*RADIO-CRAFT welcomes new and original radio or electronic circuits. Hook-ups which show no advance on or advantages over previously published circuits are not interesting to us. Send in your latest hook-ups—RADIO-CRAFT will extend a one-year subscription for each one accepted. Pencil diagrams—with short descriptions of the circuit—will be acceptable, but must be clearly drawn on a good-sized sheet.*

## A.C.-D.C. POWER PACK

A diagram of a hum-free A and B voltage supply for portable radios is shown. A 117Z6 has its plates connected




in parallel and each of its cathodes works into a separate filter network. One cathode is used as a source of A voltage and may be adjusted by varying R2. The No. 1 cathode supplies the high voltage, which is varied by R1.

By supplying the correct heater voltage to the tube, it is possible to use a 50Y6, 25Z6, 25Z5 or other rectifier tube in the circuit with excellent results.

LEHMAN M. HAUGER
*Fort Monroe, Va.*

(Note that the "A" supply should be used only with series-connected tubes drawing not more than 50 ma.—*Editor)*

## NOVEL PHASE INVERTER

This circuit has been used with very good results. It is an impedance-coupled phase inverter with inductive feedback and bass compensation.

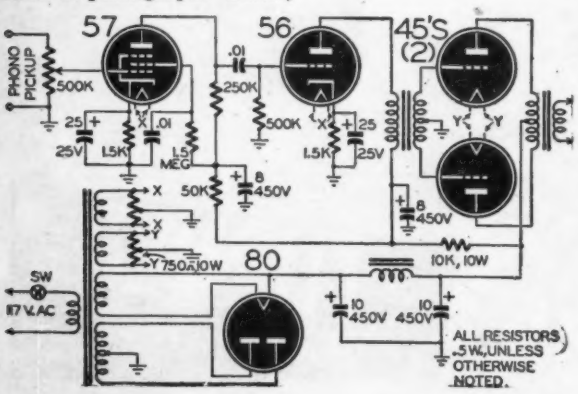
Two 6J5's are used to complete the inversion process. V1 is connected in a conventional amplifier circuit. A .05-coupling condenser couples the signal voltage to the grid of V3. The grid returns of V3 and V4 are made through the center-tapped secondary of an interstage transformer and a 100,000-ohm resistor. The grid of V2 is returned to ground through the same resistor. The voltage applied to the grid of V2 is proportional to and in phase with the voltage on the grid of V3. Resistance-impedance coupling supplies the signal voltage to the grid of V4. This is equal to the voltage on the grid of V3 but 180 degrees out of phase.

The voltage induced in the primary of the transformer is applied to the plate of the 6R7 in a degenerative feedback loop.

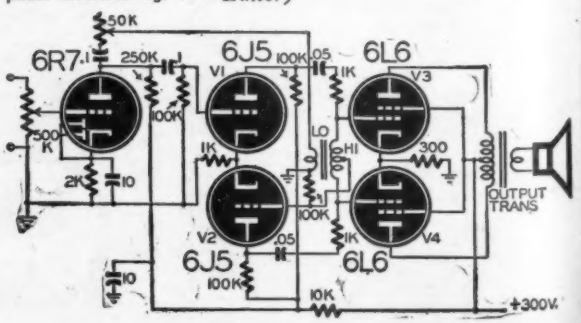
RAOUL M. FRANCO
*Alexandria, Egypt*

(The presence of V2 is not quite clear, as voltage in the correct phase relation would be supplied to V4 by the end of the transformer secondary if the center tap were simply grounded. This method of voltage inversion is well known to servicemen who have used it to keep sets in operation where a transformer primary is burned out and irreplaceable.

Feedback by means of the primary would apparently not be affected by the proposed abandonment of one of the 6J5's. Experimenters would do well to try both circuits and compare results. —*Editor)*




Left—A neat phonograph amplifier circuit. Below—A novel phase inversion rig.



## INSIDE THE HANDIE-TALKIE

*(Continued from page 684)*

the antenna, antenna loading coil and a .006-μf fixed mica condenser, as shown in Fig. 1. The plate circuit of this stage is loaded by a permeability-tuned coil and is capacity-coupled to the signal grid of the 1R5.

Crystal control of the receiver oscillator frequency is maintained by connecting a quartz crystal between the No. 1 grid and screen grids of the 1R5. Excessive oscillator voltage on the signal grid is reduced by a 7-μμf ceramic condenser connected between the signal and oscillator grids. This condenser neutralizes a portion of the oscillator frequency voltage by returning it to the oscillator grid out of phase with the internally coupled voltage.

The 1T4 and 1S5 are connected in the standard i.f. and second detector circuits common to most battery receivers. Midget i.f. transformers are used throughout. The secondary winding of the input transformer is loaded with a 1-megohm resistor to broaden the i.f. tuning.

Impedance coupling is used in the output circuit to prevent plate current from flowing through the earphone.

When the set is in operation, it is a receiver unless the "press-to-talk" button is depressed. A diagram of the complete set is shown in Fig. 2. All switches are in the "receive" position.

### THE TRANSMITTER CIRCUIT

When the set is used as a transmitter, switching converts the r.f. amplifier and oscillator-mixer portions of the receiver to a master oscillator-power amplifier transmitting circuit. The first a.f. and power amplifiers of the receiver are converted to microphone amplifier and modulator for the transmitter.

While transmitting, the "push-to-talk" button must be depressed. The circuit of the set is then changed to that of the diagram in Fig. 3, and a crystal of a frequency 455 kc. lower than the receiving crystal is switched into the circuit. The output of the oscillator anode is capacity coupled to the grid of the 3S4 r.f. power amplifier. The r.f. tank coil is switched into the circuit and tuned by a .00014-μf variable tuning condenser. This combination of coil and condenser is called a "tank" circuit. The antenna loading coil is connected in a pi network tuned by the tank tuning condenser and the capacity existing between the antenna and housing.

The dynamic microphone is transformer-coupled to the grid circuit of the 1S5. This tube functions as a speech amplifier and is resistance-coupled to the 3S4 modulator.

The grid return of the 3S4 modulator is tapped into the grid leak circuit of the oscillator tube, to provide proper operating bias of the modulator. The a.f. choke in the plate lead serves as the coupling choke for modulation of the power amplifier. A portion of the a.f. output of the modulator is applied to the earphone to provide a sidetone for monitoring transmission.

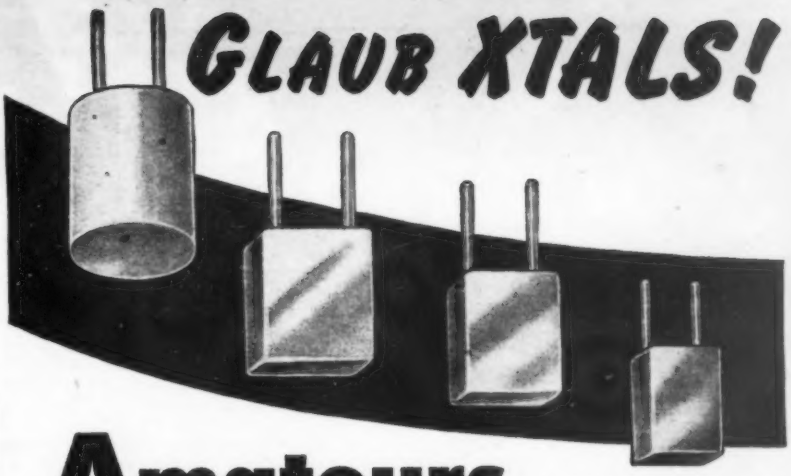
The "push-to-talk" switch is made up of 14 sections, which perform the intricate switching functions which convert the receiver to a transmitter. Each section of the switch has been given a letter to simplify a study of the diagrams. In Fig. 1, all sections of the switch are shown in the receive position. All of the switching functions are evident from the diagrams.

Many of the resistors and condensers of this set are mounted in small circular "cups" that fit around the underside of the tube sockets. Terminal lugs are mounted on the rim of the "cups" so that the parts may be connected to the external circuits. Later models abandoned the cup system and used straight terminal strips, as shown in the photo on page 684.

The transmitter is easy to adjust. A crystal and plug-in coil for the desired frequency are plugged into the unit and the antenna fully extended. The "push-to-talk" switch is held down and the r.f. amplifier tank condenser adjusted to give minimum amplifier plate current. The plate current is metered by removing a jumper located at the lower end of the chassis.

The receiver is tuned by inserting coil and crystal combinations for the desired frequency. The receiver oscillator crystal is ground to a frequency 455 kc *higher* than the transmitter operating frequency. The receiver is then aligned by conventional methods.

*(Continued on page 723)*

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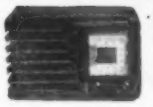

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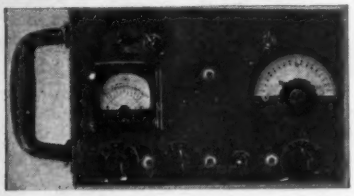
# TRY THIS ONE

## PROTRACTOR DIAL

When in need of a precision dial, why not try a protractor? Its divisions are accurately spaced and make a neat appearance, as may be seen in the photo.

The metal types are usable where the readings are referred to a graph or chart for interpolation. When it is desirable to have a direct-reading dial, a celluloid protractor is most useful. A



paper backing with the necessary markings and notations is placed behind the transparent dial so that the calibrations may be seen at a glance. A knob with a transparent hairline pointer increases the accuracy of the dial readings.

Three small screws or rivets may be used to fasten the dial to the panel.

HAROLD PALLATZ,
*Brooklyn, N. Y.*

## CODED TEST PRODS

I have found that it is possible to make test prods from auto inner tube valve stems and caps.

The valve stem is cut off close to the tube and the needle removed. A nail or long tack is driven through the valve cap with a small portion of its head protruding. A piece of insulated wire is passed through the stem and wrapped around the head of the nail. The cap is then screwed on the stem.

By selecting valve stems from red and black tubes, I have a pair of shockproof, color-coded, solderless test prods.

A. C. FROHNOPFEL,
*Bartlett, Texas*

## FADED TUBE NUMBERS

The tube type number is often printed on the side of the glass type tubes and through frequent handling, the number soon becomes unreadable.

I overcome the handicap by dipping the glass portion of the tube in ammonia and allowing it to dry. The numbers then stand out clearly. Powdered ammonia may also be used by spreading it on the surface of the tube and then dipping into warm water and allowing it to dry.

JOHN B. ROLLS,
*Verdun, Quebec.*

## BUZZ CURE

After replacing a power transformer in a console type receiver, I noticed a buzzing sound that was audible above the signal when the volume was turned low.

Wedging the coils on the transformer core was tried without success. I found that thin service cement applied to the edges of the windings and the core laminations produced a positive cure.

CLAUDE M. PREW,
*New London, N. H.*

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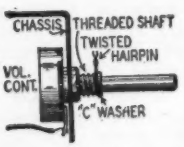
## VOLUME CONTROL REPAIR

Here is one of my favorite "kinks" for repairing noisy volume controls. It is unnecessary to remove the control from its circuit.




Remove the chassis from the cabinet and place a small hairpin between the "C" washer and the threaded bushing. A few twists on the hairpin with a pair of pliers will hold the pin in place. This will make a tighter fit between the rotating arm and the carbon strip.

SAUL KIRSHNER,
*Montreal, Canada*

## TUBE SUBSTITUTION

In servicing a receiver recently, I accidentally put a 6K7 into a 6F5 socket. To my surprise, I found the reception just as good as with the original tube. The plate and suppressor were left floating with no voltage on them. Later I checked this idea on other sets with the same results. This scheme may well be used for emergency tube replacements.

LAWRENCE MOSEMAN,
*Hibbing, Minn.*

(Before trying this method of tube substitution, it is wise to check the underside of the socket to make sure that the unused socket holes are not used as tie-points for high-voltage leads.—*Editor)*

## HANDY IRON REST

While this kink is not an original one, I find it helpful. When a hot soldering iron is left on the work bench, appliance wires are constantly coming in contact with its hot surface and becoming burned.

This inconvenience may be overcome by taking an old tube shield and screwing it just below the surface of the work bench. This makes a handy rest for the iron and it can be reached easily when needed.

A. K. MEMON,
*Karachi, India*

## SAFETY IRON

To prevent charring wires and condensers while soldering in close quarters, take a piece of thin asbestos cloth and wrap it around the lower part of the body and tip of the soldering iron. About three-quarters of an inch of the copper is left exposed. The asbestos is bound to the iron with fine wire.

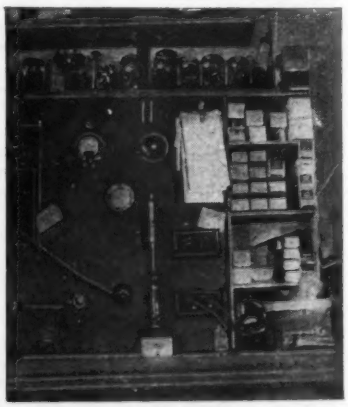
WM. A. PLEES,
*Whitehall, Michigan*

## CORDLESS IRON

The accompanying photograph shows the method that I use to prevent having a long trailing cord on the end of my soldering iron.

The handle of a heavy rubber male plug is fitted in the handle of the iron. The line wires are attached to the prongs of the plug. The iron may then be plugged into any convenient socket.

I have mounted a heavy-duty receptacle in the top of a small metal box and fixed it firmly to the top of the work bench. The iron remains upright and takes up very little space on the bench.



I find that the iron heats more rapidly when it is held in this position.

JAMES L. LANTERMAN,
*Snyder, Oklahoma*

## 430 MC WITH A 6F4

*(Continued from page 688)*

soldered directly to ends of the U. The other coupling method consists of a wire hairpin through two holes drilled in the outer cylinder (but insulated from it). As this hairpin is drawn outward the coupling decreases. Whichever coupling is used, it should be designed so that it will not interfere with the sliding assembly as it is moved up toward the top.

The simplest antenna is the half-wave dipole consisting of two portions, each about 6½ inches long. Low-impedance twin lead (75 ohms) may be used to couple the antenna to the oscillator. For best efficiency, the antenna length should be made variable. A good method is to make it of aluminum or brass with one piece of tubing sliding within another, until the correct total length is found. Since the power output is not great enough to light a bulb noticeably, the condition of optimum loading is determined by the plate milliammeter. The meter reads maximum permitted current when the coupling and loading are correct.

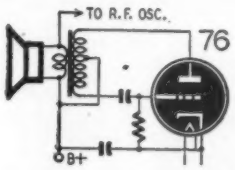



Fig. 5—Tone modulator and monitor circuit.

To carry on experiments this oscillator was used in conjunction with an audio tone modulation provided by a 76 oscillator. A PM speaker with push-pull transformer is the Hartley oscillator coil and monitor in one. The secondary connects to the voice coil. This gives a high-pitched note which can be monitored as it modulates the r.f. oscillator, (Fig. 5).

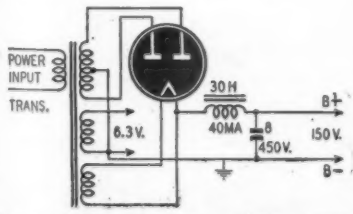



Fig. 6—The power supply and filter system.

The power supply and filter system (Fig. 6) is conventional. The transformer output is approximately 150 volts under the load of both oscillator tubes (approximately 25 ma) because of the choke input used. Since this is equal to the maximum plate voltage on the acorn 6F4 it is not necessary to reduce it in any way. The filter system provides adequately pure direct current to both tubes.

In modulating the r.f., it will be found that excessive audio input broad-

*(Continued on page 724)*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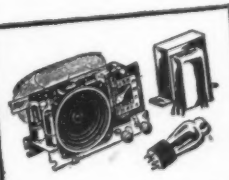

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## CONVERSION OF ARMY RADAR OSCILLOSCOPE

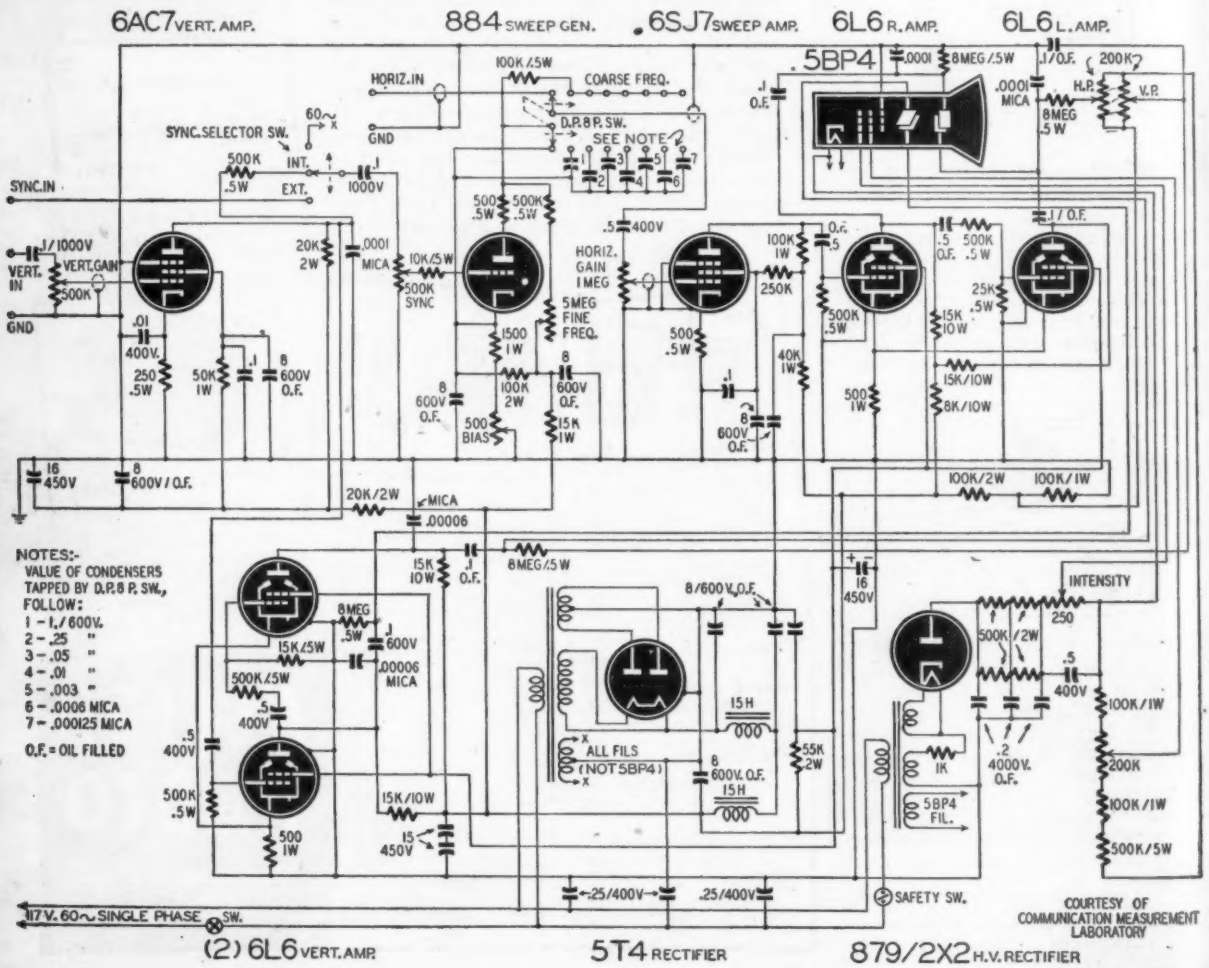
**?** *Recently I purchased one of the BC-412-A oscilloscopes. This "scope" was used by the Army in radar installations. I would like a diagram showing the changes necessary to convert this "scope" so that it may be used for radio servicing.—(Many Readers).*

**A.** A diagram is shown that will enable you to convert the oscilloscope for radio servicing. The 6L6 pulse and sweep generators and the 6SJ7 spread amplifier are discarded and an 884 gas triode oscillator sweep circuit is added to the circuit. Two controls have been added which permit the operator to make coarse and vernier adjustments on the sweep frequency. Input jacks for external synchronizing voltages and for the horizontal and vertical amplifiers are used for external coupling to the "scope".

The parallel vertical amplifier is converted to push-pull for better performance. The vertical sensitivity is approximately .045 volts per inch and the horizontal amplifier has been altered to increase the gain to 0.3 volts per inch.

All leads in the input circuits of the horizontal and vertical amplifiers should be well shielded. The long leads should have the shields grounded at several points. Hum and microphonics in the vertical amplifier may be caused by a defective 6AC7.

Extremely high voltages are used in some parts of the 'scope circuit and all precautions should be taken to avoid bodily contact with these circuits as this will result in DEATH or SERIOUS INJURY. When working on the unit, all high-voltage condensers should be discharged each time that the power is turned off. A well-insulated metal screw driver may be used to short the terminals of each of the condensers.



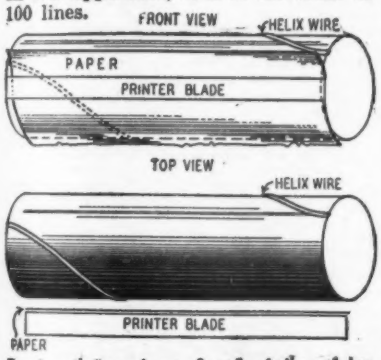
## NEW FACSIMILE IS FAST

*(Continued from page 680)*

giving a check on what is going out over the air. The one at the right may be patched into various points in the transmitting equipment, thus affording a means of trouble shooting.

The scanner used in the Hogan apparatus is of conventional type. Copy wrapped around a revolving drum is scanned by an electric eye in terms of gradations of shade contained within a very narrow horizontal line.

To accomplish this, the electric eye is focussed upon one tiny rectangular spot so that during one revolution of the drum it scans around the cylinder in terms of this tiny spot. By moving the electric eye along the drum a distance equal to the width of the spot during each revolution of the drum, the copy is scanned from left to right in a series of slightly slanting contiguous lines from top to bottom of the page. The number of these lines in one inch is called the definition of the system. In this apparatus, it is in the order of 100 lines.




**Front and top views of a facsimile printer.**

Meanwhile, at the recorder, a recording element causes a marking spot of the same size to travel across and down the recording paper at the same speed as the scanning spot. Since these signals are broadcast with the speed of light, the marking spot controlled by the fluctuating facsimile signal current produces a facsimile of each tiny area in the original at the corresponding area of the recording paper.

Although scanners have been more or less alike in all systems, recorders differ greatly. Some simply reproduce the beam of light on photographic film, which is later developed. In others, a point moves across a drum on which carbon paper is spread over white recording paper. Pressure varies with the modulation, causing a heavier or lighter deposit of carbon on the backing paper. Most modern systems are electrical in nature. Current from the scanning point passes through the paper, causing a chemical darkening which increases with the quantity of current passed.

The area of the marking spot is determined by the intersection of a "helix" (spiral) wire wound around a cylinder on one side of the paper and a strip of metal (the printer blade) mounted

*(Continued on page 711)*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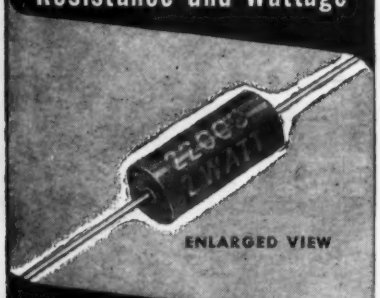


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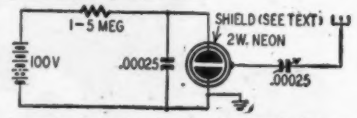
# NEW RADIO-ELECTRONICS PATENTS

## R.F. INDICATOR

George E. Colman, Red Bank, N. J.
Patent No. 2,395,850

R.F. TRANSMITTERS are tuned and modulation checked conventionally by thermocouples and meters, both of which are rather expensive and delicate. This new circuit should be of interest to amateurs and others since it enables a circuit to be correctly tuned by using only an ordinary neon bulb.




A conducting ring is placed around the neon bulb and is connected to a pickup device such as a small antenna which is introduced into the r.f. field. The small variable condenser controls the electrostatic excitation to the bulb. One of the bulb plates is grounded, and both are connected across a small condenser which equalizes the discharge so that each plate shows approximately the same glow.

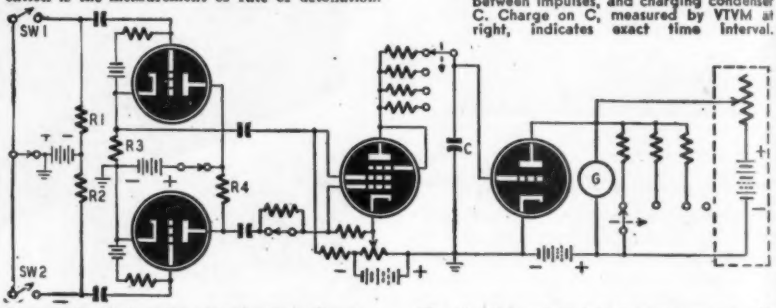
An auxiliary d.c. circuit is connected and adjusted so that the neon is only slightly ionized. The added r.f. power causes a corresponding increase of ionization. Relative r.f. magnitude may be indicated by the variable condenser setting necessary to reach a given degree of ionization.

Typical circuit constants are given in the diagram.

## ELECTRONIC CHRONOSCOPE

Carrol R. Nisewanger and Frederick W. Brown, Pittsburgh, Pa.
Patent No. 2,395,902

THE measurement of very small time intervals (of the order of 10 microseconds) is accomplished by this instrument. One practical application is the measurement of rate of detonation.




At left, two thyratrons which switch center tube, causing current flow in interval between impulses, and charging condenser C. Charge on C, measured by VTVM at right, indicates exact time interval.

In explosive design, for example, it is often necessary to know the time interval between the instantaneous detonation at given points along an explosive.

The circuit uses two thyratron tubes connected to a switching tube. The latter tube, a pentode, is adjusted as follows. The screen grid is biased below cut-off, but an applied positive pulse will restore the tube to a conducting condition. If a negative pulse is applied to the control-grid immediately thereafter, the tube cuts off again. The pentode circuit is equivalent to an R-C circuit which is closed and then opened. As a result the condenser C becomes charged to some value depending upon the time interval of conduction. A meter across C may therefore be calibrated in terms of that time interval.

Closing Sw1 starts the interval being measured. The voltage drop across R1 transmits a positive pulse to the upper thyratron which breaks down. The voltage drop across R3 applies a positive pulse to the switching tube which begins to conduct and charge the condenser C. The completion of the interval is marked by closing Sw2, which produces a voltage drop across R2. The resultant positive pulse fires the lower thyratron and there exists a voltage drop across R4. A negative pulse is therefore transmitted to the pentode control grid, cutting off the plate current.

The voltage to which C has been charged is measured by a vacuum-tube voltmeter which includes the usual balancing-out circuit. This permits setting the meter G to some reference point before measurement. Voltage across C (and therefore time interval) is indicated by a corresponding decrease of meter indication.

The circuit may be calibrated by closing the key switches mechanically at known small time intervals. To measure the rate of detonation of an explosive, each switch may consist of two fine wires placed close together. When the explosion reaches a switch, the released ions act to close it. With a slight change of circuit it is possible to utilize a circuit break to fire each thyratron.

The circuit is adapted to measure over a wide range of values by providing several values of resistors in the condenser charging and galvanometer circuits.

*Suggested by Bill Wortman, Oakley, Ill.*

"I'm trying to tune in another station!"

# TECHNOTES

**. . . . SPEAKER REPAIRS**

When a speaker cone is warped so that it will move freely in only one direction, it may be repaired by springing it back in the correct position and blocking with wadded paper, felt or a small weight. While the cone is blocked in this position, the corrugated rim of the cone is wet with water and then allowed to dry in this position. The cone will retain this position when dry and will be free from scraping.

HUBERT WATKINS,
*Gulfport, Miss.*

**. . . . BATTERY POWERED RADIOS**

Operating voltages of 1½-volt oscillator tubes used in many sets is very critical and cannot be determined with a tube tester.

To prevent unwarranted complaints soon after a set has been serviced, the minimum effective filament operating voltage should be determined. This is done by making up a separate extension cable for the A-plus line. A 10-ohm rheostat is inserted in the lead and the resistance increased until the tube ceases to oscillate. If it refuses to oscillate at any voltage below 1.1, it should be replaced, as it will not get all of the usable power out of a set of batteries.

In making this test, a good voltmeter should be connected directly across the filament terminals *at the tube socket.* A high-resistance or vacuum-tube voltmeter connected to the stator of the oscillator tuning condenser will indicate the instant that oscillator fails.

GERALD EVANS,
*Ola, Arkansas*

**. . . . ZENITH 8S611**

Sharp crackling noises while tuning this model may be caused by corroded contacts on the tuning condenser gang. Clean all bearings, fly-wheel, counter shaft and tuning condensers by applying carbon tetrachloride with an art brush. The bearings are then lubricated with a light film of machine oil.

CLAUDE M. PREW,
*New London, N. H.*


## DELIVERY FROM STOCK

*Aerovox Can Type Condensers:*
GLS 450 V. 8 mfd., net $0.89; GL 450 V., 8 mfd., $0.89; 2GL 450 V. 8-8 mfd., $1.33; GL475 V. 8 mfd. $1.22; GL 450 V., 12 mfd., $1.16; GL 450 V. 20 mfd., $1.43; PRV 450 V., 10 mfd., $0.95; PRV 450 V., 40 mfd., $1.81; GL 600, 8 mfd., $2.16.

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2 In. P.M., 2ZMP, $1.55
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**AEROVOX TYPE - 89**

Hermetically-sealed metal-can container fully sealed against oil leakage or moisture penetration.

Case is insulated, or not connected with the capacitor section.

Center mounting strap and outer insulating tube supplied.

In 400, 600, 1000 and 2000 volt D.C.W. ratings. Choice of popular capacity values.

Sizes from ½ x 1 7/16" to 1 1/16 x 2 3/16".

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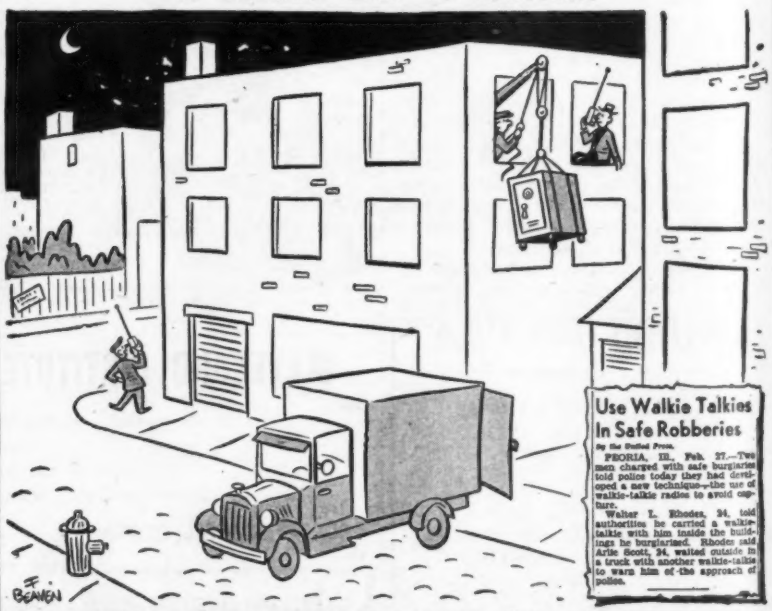
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## NEW FACSIMILE IS FAST

*(Continued from page 707)*

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## Radio Thirty-Five Years Ago

**In Gernsback Publications**

**HUGO GERNSBACK**

*Founder*

| | |
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| Modern Electrics | 1908 |
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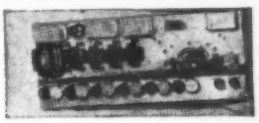

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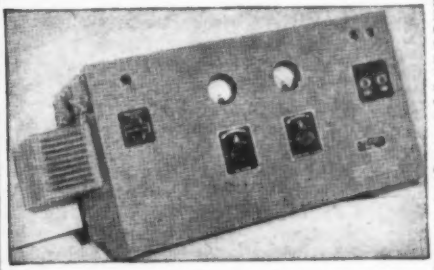

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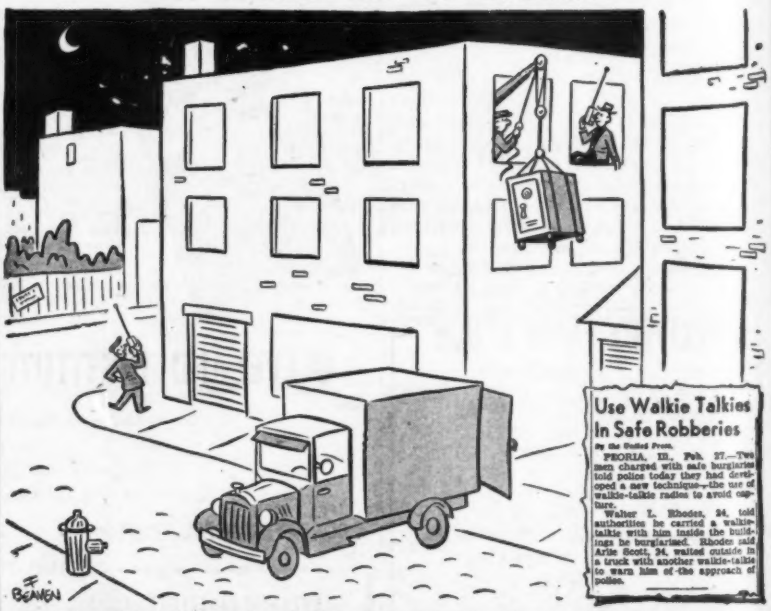
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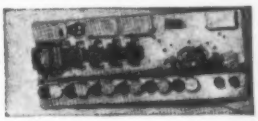
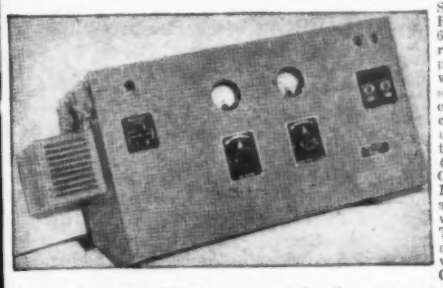
| 1.7H .160 Amps chokes Good for choke Modulation | 1.49 |
| Steatite miniature coil forms 1½x1½ dia. | .25 |
| Ceramic coil forms, adj. base 2½x1½ dia. | .45 |
| Dynamotor, made by G.E., others: 28v/1.1 A input 250v/.060 A output, for SCR-274 or ARC-5, used, perfect condition | 2.95 |
| Selsyns, Diehl, 115v/60cps per pair | 7.75 |
| Klystrons 723A/B new | 10.00 |
| SCP1, SCP4 with tube socket | 10.95 |
| Micawave Fittings in stock | |



**BC-406. Frequency range 201 mc. to 210 mc. I.F. freq. 20 mc.; 2 mc. bandwidth. 15 tubes.**

**$29.95**



Signal Corps type BC409 from SCR-268 Radar set. Designed for 115 volts. AC 60 cycles. This unit developed the initial radar pulse and contains valuable component parts that valued individually would, in sum, cost several times the selling price of this unit. Fine buy for experimental work, or for anyone who can use the component parts. Slightly used. Following are a few of the items that make up the unit. 1—304TL (Eimac) triode 3—2 mfd. 4,000 W.V. GE Pyranol condensers. 1—3200 volt 150 MA power transformer. 1—Variac 5 amps. General Radio type CU 200. 1—5 volt 26 AMP fil. transformer (for 304 TL). 1—2.5 volt 10 Amp. fil. transformer (5000 volt insulation). 1—1 mfd. 1,000 volt GE Pyranol. 1—2 mfd. 1,000 volt GE Pyranol

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## TELEVISION FOR TODAY

*(Continued from page 683)*

been adopted. First, instead of sending the electron beam straight across the screen, as shown in Fig. 2, it is slanted slightly downward to achieve the effect illustrated in Fig. 4. In the first method (Fig. 2) it would be necessary to quickly drop the beam as it was moving from right to left during the retrace interval in order to place it in position for the next line. While this can be done, it is not as simple as the method of Fig. 4. In that method, a combination of vertical and horizontal deflection voltages cause the beam to travel at a slight incline. When the right-hand side of the image is reached, the beam has been lowered to position for the next scanning run and need only be moved straight across during the faster retrace period.

The second modification is in the horizontal-line scanning sequence. It is made to overcome a flickering effect that would otherwise appear. Whenever a series of related still films are projected on a screen, they can be made to appear continuous if the rate of presentation is greater than 15 per second. However, because each frame is so (relatively) slowly replaced by the succeeding frame, a definite flicker is present. By the use of special shuttering methods, we can eliminate the flicker entirely. In a television receiver we have an analagous situation. Each complete scanning run represents the equivalent of one frame of film. If we have too few presentations per second, flicker will be evident. The object, then, is to cause the beam to scan so rapidly that never does the image light begin to fail. One solution is to have 60 full scannings per second. A better solution, however, and one that accomplishes the same effect at a lower repetition rate is the process known as interlaced scanning. (The desirability of a lower repetition rate is because the bandwidth requirements vary directly with the number of images sent per second.)

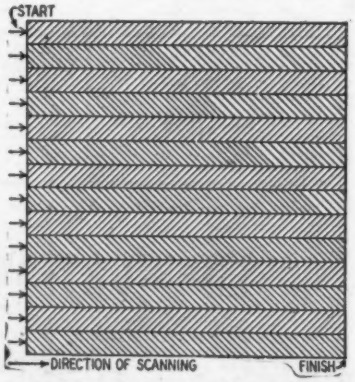


Fig. 3-a—The usual horizontal scanning path.

The basis of interlaced scanning is to have the electron beam cover first all the odd lines, then come back and cover the even lines. Hence, only half of each image is being sent at one time. However, the eye cannot separate the halves, and visually it appears as if the effective rate is actually 60 frames per second, whereas it is only 30. By keeping half of the image always before us, all traces of flicker are cleverly eliminated. The even lines are sent in 1/60 of a second, the odd lines in 1/60 of a second, or a full image is sent in 1/60 + 1/60 or 1/30 of a second. For each second then we get 30 frames. The use of values like 30 and 60 is directly connected to the frequency of our a.c. power mains. In England, where the power frequency is 50 cycles, values of 25 and 50 are employed.

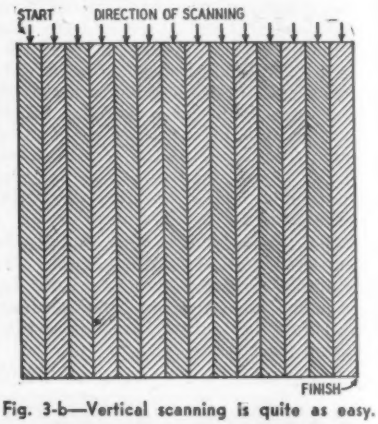


Fig. 3-b—Vertical scanning is quite as easy.

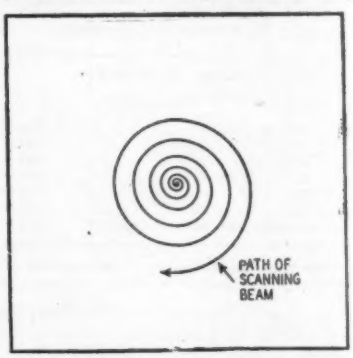


Fig. 3-c—A practical pattern in some cases.

To differentiate between the two rates, we say that the frame frequency is 30 per second, while each half of a frame (either the odd lines or the even) is known as a *field*. From above, the field frequency is 60 per second; add to this the fact that 525 horizontal lines are contained in each image or frame and we have the standards set for the present television system.

A complete scanning of an image is indicated in Fig. 5. Field 1 begins with the beam at point A. It then sweeps to the right, slowly scanning out the information until point B is reached. Now a blanking pulse is inserted into the signal, cutting off all scanning action until the beam has been brought by a horizontal synchronizing pulse to point C,

the next odd line, or number 3. This is repeated for each odd horizontal line until the end of Field 1 is reached at point D, the extreme lower right-hand corner of the image. Now the signal is again blanked out while a *vertical* synchronizing pulse brings the beam back to point E, the start of Field 2. Note that point E is in the middle of the image and represents a point that is 262½ lines from the start of Field 1,

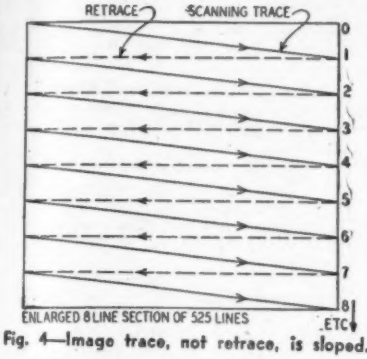


**Fig. 4—Image trace, not retrace, is sloped.**

point A. The rather odd figure of 262½ is due to the fact that the entire image contains 525 lines and one field is half of this amount. When the second field has completed its scanning run at G, the synchronizing pulse brings it back into position A for the next frame.

### THE IMAGE DISSECTOR

The Iconoscope camera tube finds wide application, but other tubes do exist. One type, developed by P. T. Farnsworth, is the *image dissector* tube shown in Photo A. An internal view, providing more detail, is given in the drawing on page 683 and will form the basis for our explanation. The scene to be televised is focused onto the internal photosensitive cathode by an external optical lens system. Under the action of this incident light, electrons are given off in proportion to the

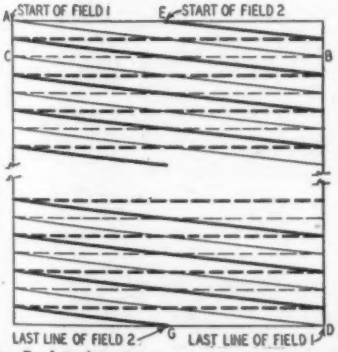


**Fig. 5—Interlaced scanning prevents flicker.**

light intensity at each point. The electron distribution thus leaving the cathode surface is electrically equivalent to the distribution of light and shade focused on the cathode plate by the lens. A positive voltage located at the opposite end of the tube forces this electron cloud to travel forward, while electromagnetic deflecting coils keep the

*(Continued on following page)*


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## TELEVISION FOR TODAY

*(Continued from previous page)*

emitted electronic picture pattern intact.

In the Iconoscope, the charge remains on the mosaic, while an electron beam scans the surface. In this tube, scanning is accomplished by bringing the electronic charge distribution to the *scanning aperture* and then swinging the electronic image back and forth so that each section of the emitted charge has a chance to pass into the opening and subsequently cause a flow of current in the external circuit. The magnetic field shifts the whole electronic image up and down and from side to side, exactly as the scanning beam is moved in the Iconoscope, until a sample of the electronic charge has been obtained from each section of the image, in the manner dictated by interlaced scanning.

As long as light is focused on the photosensitive cathode, electrons are being emitted in a continuous stream. Hence, no matter what section of the image is being scanned at some particular moment, electrons will always be present to enter the scanning aperture.

The relatively few electrons that enter the scanning aperture at each instant would be far from sufficient to produce clear signals in succeeding amplifiers. In all probability, the random noise voltage that is part of every tube would be strong enough to mask the signal beyond the point of recognition. To overcome this handicap, an *electron multiplier* assembly is made part of the scanning system. Incoming electrons hit specially coated plates that emit several electrons for each impinging one. These electrons now go to a second plate, where again a multiplication occurs. By repeating this process eleven times, the very weak initial signal currents are amplified to a point where all masking voltages are readily overcome. Now the regular line amplifiers receive the signal and pass it on to the transmitter.

**SOUND WAVES** sent into the Pacific Ocean off the coast of California by Navy sonar devices bounce back from 1000 to 1500 feet below the surface when they strike a 300-mile wide oceanic layer suspended between the floor of the ocean and the surface, scientists at the Navy Electronics Laboratory of the University of California Division of War Research **reported recently.**

This sound-stopping layer extends from Point Mendecino, 200 miles north of San Francisco, to Cape San Lucas at the tip of Lower California, and is the deepest oceanic layer known.

Scientists are not sure what composes the layer, but one theory is that plankton, small marine animals, make up the sound barrier. Other suggestions are that the echo may be caused by larger fish feeding on plankton or that gas bubbles from the undersea life reverberate sound.


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tuning of the oscillator by the circuit to which the r.f. lead is connected. It is connected directly to male chassis mount microphone connector, J1. A single shielded cable, terminated in a female microphone connector, feeds either the r.f. or a.f. to the external circuit. This is clearly shown in Photo A. This photo also shows the general arrangement. S1 is shown in the lower left hand corner with the r.f. jack immediately to its right. The r.f. attenuator can be seen above, and slightly to the left of, S1. The National ACN dial adds finish to the Transigenerator's appearance, suggesting a professional model.

### THE A.F. OSCILLATOR

The a.f. oscillator follows the same design principles used in the r.f. unit. The coil and condenser L4 and C5 (the condenser marked ".1, see text" in Fig. 2) determine the frequency of operation, which in this case is 400 cycles. A separate a.f. attenuator is employed. It is connected directly across the tank. The a.f. output is taken from the potentiometer and feeds the microphone male jack J2 through a blocking capacitor. A cathode resistor biases both the control and suppressor grids, and with the correct plate and screen potentials given in Fig. 2, places the operating point at the center of the linear portion of the tube's operating curve. The result is an essentially pure 400-cycle note (measured distortion 3 percent) a result not too often encountered in commercial signal generators. For proper operation of the a.f. oscillator the modulation switch, S2, should be in the "off" position.

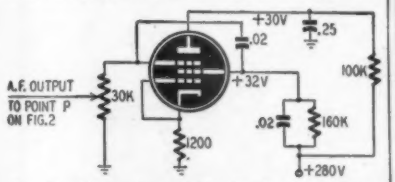



Fig. 3—Alternative R-C circuit for audio.

A maximum audio frequency voltage of approximately 4 volts r.m.s. may be expected at the A.F. output jack. This is ample for most purposes.

A few words regarding the L4-C5 frequency determining network is in order. Trouble may be experienced in obtaining a suitable inductance. The value of C5 is given as .1μf. Actually, *the capacitor used measured .125μf.* Other .1μf capacitors checked were also found to have an average capacity of .125μf. This means that an inductance of 1.27 Henries is necessary to tune to 400 cycles. Calculations show that an inductance of 1.25 Henries will resonate at a frequency of 403 cycles with a capacity of .125 μf. This is close enough to 400 cycles.

An inductance of 1.25 Henries may not be available. The one used in the Transigenerator was obtained by placing stacked sheets of transformer laminations inside a multilayer air core coil, whose previous inductance was approximately 350 millihenries. The laminations were taken from a discarded transformer and cut to fit. L4 may be seen in the lower right hand corner of chassis in photograph below.

Suggested combinations of L and C to tune to 400 cycles or thereabouts are tabulated below and may serve as a guide to the prospective constructor.

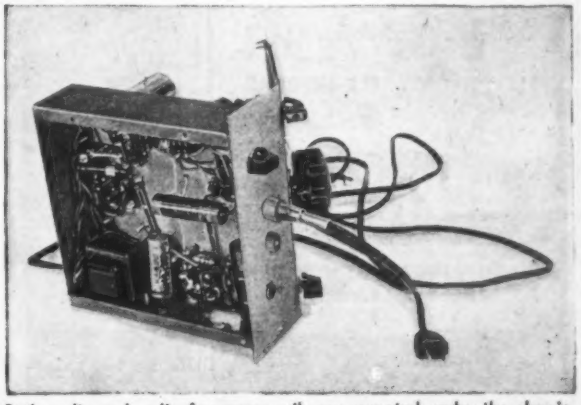
| L (H) | C (μf) | Remarks |
|---|---|---|
| 0.5 | .316 | voltage |
| 1.0 | .159 | output decreases |
| 1.25 | .125 | |
| 2.0 | .08 | distortion |
| 4.0 | .04 | of wave increases |

If it is impossible to obtain a suitable L4-C5 combination, an R-C tuned version of the Transitron may be employed. The circuit is shown in Fig. 3. This circuit is simpler and requires no inductance. It was not used in the Transigenerator only because it was considered more expedient to operate both plates (r.f. and a.f.) at the same potential of 9 volts (as per Fig. 2), with one common by-pass capacitor. Moreover, a suitable inductor for L4 was easily obtained.

If the values in Fig. 3 are followed closely the output waveform will also approximate a sine wave much more closely than average signal generators.

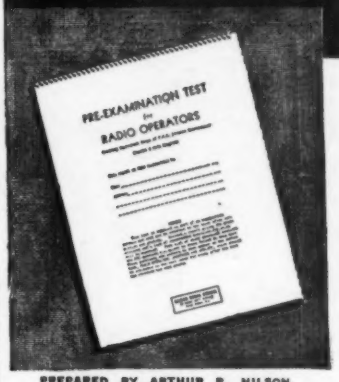
To obtain unmodulated r.f. output at jack J1, the modulation switch S2 is placed in the "off" position. For a.f. modulation at 400 cycles, S2 must be placed in the "on" position. Grid modulation of the r.f. oscillator then takes place at the audio rate of 400 cycles per second. Percentage of modulation is controllable. Two volts (r.m.s.) is necessary to modulate the r.f. oscil-

*(Continued on page 722)*



Both audio and radio frequency coils are mounted under the chassis.

PRE-EXAM TESTS
For Commercial Radio Operator FCC LICENSE EXAMINATIONS

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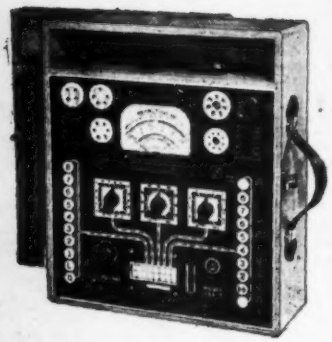

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## RADIO IN THE ATOM TESTS

*(Continued from page 682)*

radiation or the measurements of gamma rays, neutrons, etc.

Among the instruments used by this section are: spectrographs to obtain the spectral distribution of the first flash; photo-electrical units to record the intensity of the first flash as a function of time; and bolometers to measure the total radiant energy emitted by the first flash. Unfortunately, the findings in this field only, the instruments used and the techniques employed are classified under the security regulations of the Manhattan Engineer District and will not be released for publication till some time after the tests are completed.

Four Army Air Force's B-29's will be prepared to track and photograph the cloud resulting from the blast to determine its persistency and radiological activity. Ground photographs will be made from fixed installations on 75-foot steel towers, placed at strategic points on Bikini Atoll. All these cameras will be radio controlled.

Radio and television-equipped aircraft will play an important part in the tests. Radio-controlled drones (Photo A) carrying radiological instruments will be directed to the scene of

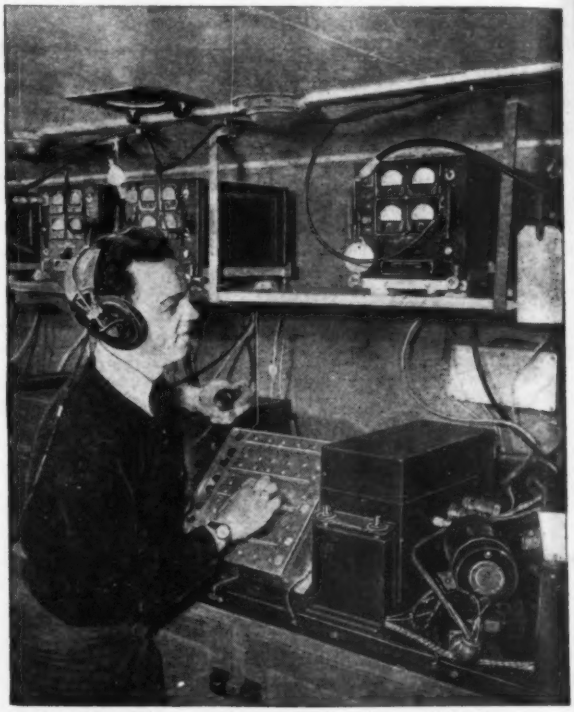


Photo B—The radio control room for launching and landing drones.

Photo C—AAF pilots preparing for the tests take refresher in electricity and electronics.

the blast and information will either be radioed back to the observation ships or the drones will be directed back to the ships. A new type of long-range, high-altitude, high definition television system (See RADIO-CRAFT, May 1946) installed in the nose and waist of reconnaissance planes equipped with transmitting apparatus will enable Task Force One officers to view at close hand the destruction and effects of the bomb, which would otherwise be impossible (or at least highly impractical in terms of lives.)

The drones are scheduled to fly close enough to the atomic bomb blast so that sensitive scientific and photographic instruments stowed in their cockpits will record what happens when an atom bomb explodes on its target. Each of these drones is controlled by a plane from which a Navy pilot will maneuver his drone, keeping it always in sight and able to identify it by its colored tail. The drones are red overall, with a colored fin and rudder matching a color painted on the engine cowling of the Queen Bee plane which controls its flight.

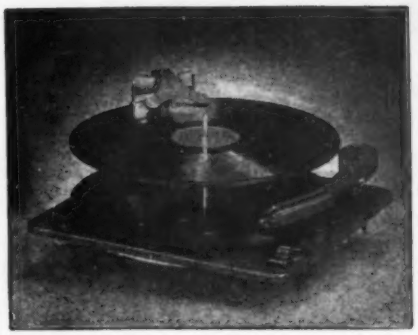
The drones will take off under the control of a Navy radio specialist in a radio control *truck* (photo B) parked on the carrier flight deck. When they are 100 feet in the air, the Queen Bee pilot takes over from the truck. After the explosion, the Queen Bee planes and those drones that come through the tests will fly to Roi Island where they will be landed and the data which was recorded by their sensitive instruments removed for study by the atomic scientists.

All AAF men participating in the tests are required to take refresher courses in subjects pertinent to their specialty. Radio operators and technicians will be schooled in the intricacies of radar and loran, both of which will be used in the tests. (Photo C)

### TROPICAL DRY BATTERY

The new Mallory dry cell illustrated above is based on a new metal-electrolyte combination. Unlike older cells which use zinc, carbon and sal ammoniac, this one operates through the chemical reaction of zinc and mercuric acid. Less than one-third the size of the regular cell, shown at the left, it has several other advantages.


Erwood SOUND EQUIPMENT



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The operating mechanism developed for this Changer utilizes a steel spiral which is welded to the bottom of the turntable. This gives an extremely compact, reliable operating member. Control has been simplified, a single button performs all functions.
Records are held on a single post, with push off mechanism and an offset spindle, the design of which is such that the records are subjected to a minimum of wear. Model 105 will play 12, 10" or 10, 12" records. Needle pressure is exceptionally light which reduces the sidewall wear, and assures long record life.
All operational parts are of stamped steel construction, adequately rustproofed, Operation is both simple, positive, and exceptionally quiet. Driving belts, gears, etc., have been eliminated. The heavy steel mounting plate, upon which the assembly is mounted, measures 12" x 12½"; height required over the top of the mounting plate, 4⅜". During the playing operation, all operated mechanism is at rest, assuring long life and silent operation. Turntable is attractively flocked, pickup arm and mounting base are walnut hammerloid finished.

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## SECRET COMMUNICATION

*(Continued from page 673)*

back found the reason why bats can fly in a dark room criss-crossed with wires yet never once fly into the wires or collide with the walls. The reason is that bats generate supersonic sounds in their throats so high that human beings cannot hear them, yet when the bat makes these sounds they are reflected from whatever objects are in its path and return to its ears. A sort of audible radar. Consequently, a bat never collides with any solid object. The scientists who investigated the bat's sounds had to translate these sounds into audible sounds for human beings, which they did by means of electronic apparatus.

Now then, it seems a short step from this to generate inaudible sounds in a simple apparatus, then modulate the sound the same as we do with a radio wave and use it as a carrier either for voice or for code.

At the receiving end these supersonic sounds are made audible to the human ear by means of special amplifiers, and communication is accomplished.

Such a system would seem to have possibilities for secret communication for war as well as peace purposes, and no doubt many applications can and will be found for it. Furthermore, as sound can be focused by parabolic reflectors, the same as light rays or infra-red rays, the system becomes more or less secret if no one is in the direct line of the transmission.

Supersonics thus may open up a new system for communication. To the best of our knowledge little communication has been carried on by this method.

We wish to advance some additional thoughts along these lines for still greater secrecy and safety from detection.

We can adopt the principle of splitting communication. Nothing prevents us from doing this, using any combination of the means described above. We can thus use a separate light ray transmitter and a separate infra-red transmitter, either side by side (or separated a suitable distance) and then send out our communication *over both these channels*, splitting up the communication. Then if anyone attempts to intercept the light ray itself, only gibberish results. If he succeeds in tapping the secret infra-red channel, likewise nothing intelligible can be heard.

Unless you have the "key" and know what is going on and know *what* types of channels and media are used, you are not likely to guess the secret at once. Not only that, but you also have to know the exact location, all of which puts additional handicaps in the way of the unauthorized listener.

At the receiving end of the key receiver the light-ray transmission and the infra-red ray transmission are combined and the speech (or code) is resolved into intelligible communication.

We need not stop here, but we can "scramble" our channels in many ways. Thus we can have infra-red plus supersonic sound. We can have radio plus infra-red, or we can have light plus radio. Thus we obtain dozens of different combinations, enhancing the secrecy many fold.

In time, particularly during war and for war purposes, there is no reason why only two channels of different media should be used. One can send out split communications over six or more different channels, and only by combining *all* these channels would you have a complete intelligible communication.

A fascinating new field in communication, which so far has not been exploited at all, is thus opened.

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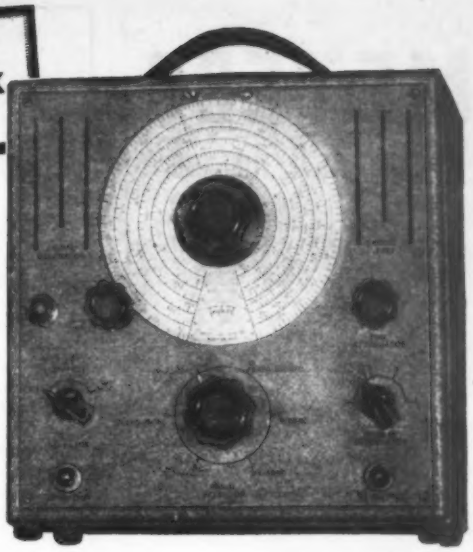

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## NOMOGRAPH CONSTRUCTION

*(Continued from page 701)*

edge can cross only two lines to obtain one product, so it is necessary to work such a chart in two steps. First, A × B =Q, then Q × C = D. Since it is not necessary to know what the product Q is (because we are interested only in D) such nomograms have an uncalibrated "reference line" which is the Q scale just mentioned. The product of A and B is located on this line with a light pencil mark, which is used with line C to give the solution on scale D.

Other nomograms (usually beyond the ability of the beginner to construct) combine multiplication with addition by making one of the factors a composite number containing one of the factors and the added term. Others represent one or the other of the quantities by a curved line, and can represent factors which vary other than in a linear mathematical manner. Some of the simpler of these may be handled in a forthcoming article.

References:

**Nomograms**, Carl P. Nachord, *General Electric Review*, May, 1944. Page 13.

**Nomograms — How to Make and Use Them**, R. Howard Cricks, *Electronics and Television & Short-Wave World* (British), November, 1940. Page 495.

**Alignment Charts; Construction and Use**, Maurice Kraitchik, (D. Van Nostrand Co., New York).

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## RADAR ROCKETS

*(Continued from page 679)*

auxiliary jets on either side of the radarocket).

The revolving lobe describes a circular path (forming a *cone* as shown in Fig. 5-c). A target located on the reflector axis line gives a resultant echo signal (on the receiver) having an identical amplitude for every position of the rotating lobe. If the target is not on the center-line of the reflector axis, the echo signal will vary in amplitude sinsusoidally as the lobe is rotated. Whenever the lobe's center (or axis line) approaches the target there is an increased strength of reflected signal. As the lobe rotates further, so that its axis or center line recedes from the target focal line, a *weaker* signal results. The direction of the target from the reflector axis is thus indicated by the relative phase of the variation or rise and fall in strength of the received echo signal.

Fig. 7 shows two positions of the rotating lobe and the relative strengths of signals reflected from the target in different positions. (See also Fig. 4).

The preponderant strength of signal received on the radarocket (when the target is off to one side of the reflector axis) is caused to correct the course of the rocket. With the conical scanning method (which was employed on the SCR-584 Radar) applied to the flying bomb, it should hit the enemy target—once it comes within range.

When reflected signals of varying strengths are picked up on the radarocket's receiver (for a target off the centerline of the reflector axis) these signals are integrated through suitable circuits fed into an *amplidyne* control amplifier and finally impressed on an amplidyne generator (controller). The rotor of the generator turns in accordance with the degree and polarity of the impressed current and relays this position to a *servo motor* in the rear of the radarocket. This servo may operate the vertical and horizontal rudders (or fire auxiliary course-correcting rockets).

The problem of identifying an enemy rocket poses a nice problem for the engineers. By making careful observations

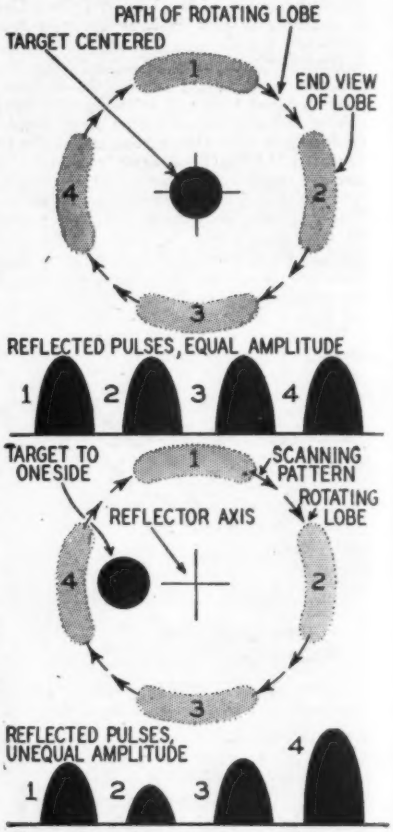


Fig. 6—Conical scanning beam and its target.

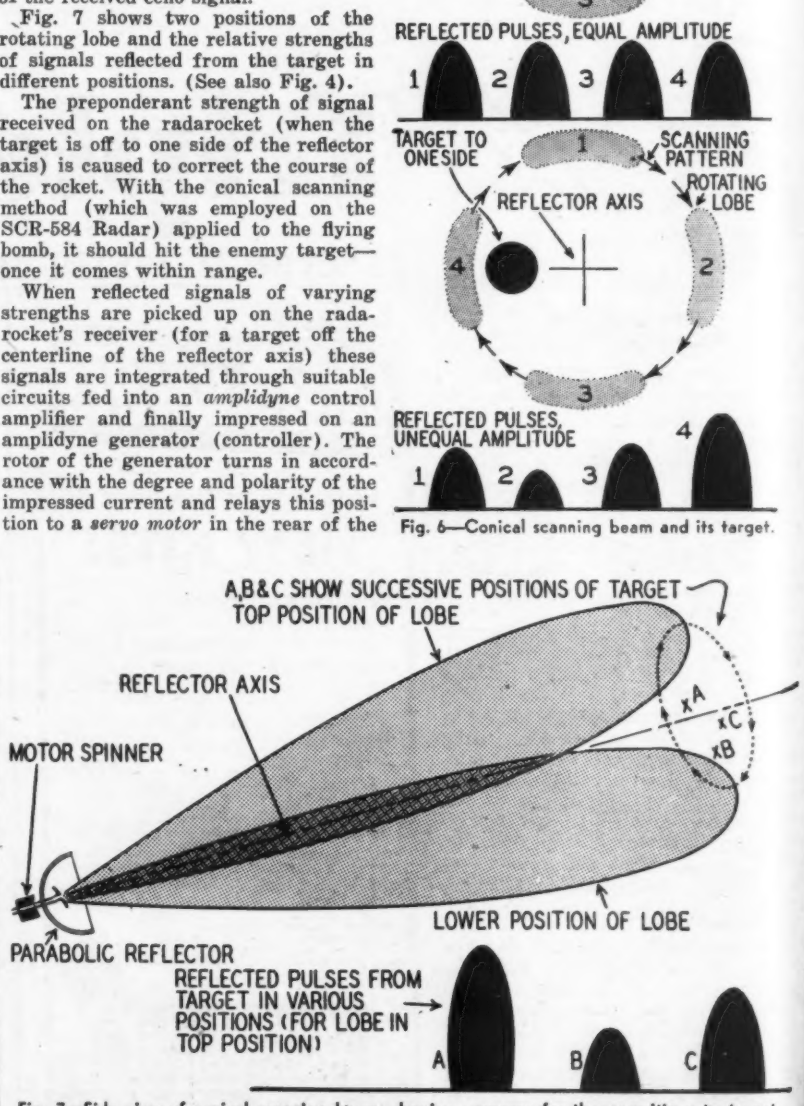


Fig. 7—Side view of conical scanning beam, showing response for three positions to target.

of the relative speed and the course followed by a rocket over a given period of time, it becomes possible to plot its probable course, and be prepared to shoot it down long before it comes near enough to be dangerous.

Planes might also be used as carrier devices, bringing rockets to within a few hundred miles and releasing them. However, if all friendly planes and rocket devices are fitted with IFF (Identification, Friend or Foe—See RADIO-CRAFT February, 1946) any flying craft which did not give a satisfactory response would at once be classified as *enemy* and counter-attack rockets sent out after it.

These precautions would be necessary only in peacetime (during periods when surprise attack might be feared). In war, all friendly planes would be grounded, and whereabouts and movements of friendly military planes definitely known. Thus any unknowns could be classed definitely as enemy.

The idea for the radarocket was discussed with an expert who had considerable experience with radar sets used by our fighter planes in hunting down enemy planes at night or in foggy weather. It seemed from the results obtained with radar in aerial warfare that the radarocket automatic direction control could be depended upon to work up to distances of about a mile.

In radar reflections the area of the target which is to reflect the wave projected against it has a great deal to do with the strength of the signal sent back to the receiver. The larger the target the stronger the reflected signal. The reflecting area of the enemy flying bomb would admittedly be rather small, but modern radar has demonstrated almost unbelievable sensitivity; in some cases the tiny periscope of an enemy submarine was a sufficient target to reflect the radar wave sent from a scout plane several miles distant.

## HOW MINE DETECTORS WORK

*(Continued from page 677)*

and is hooked up in a Colpitts circuit. A .07 μf plate and 0.25 μf grid condenser and the transmitting search coil make up the oscillating circuit elements.

The other two tubes are the audio amplifier. The signal picked up by the receiver search coil is coupled to the grid of the first amplifier tube through a 4 to 1 ratio step-up audio transformer. Condensers across the primary resonate the circuit roughly to 1,000 cycles. The tube is impedance-capacity coupled to the next and last stage. A half-megohm potentiometer in the grid circuit of the second tube acts as volume control, and headphones are connected into the plate circuit through a blocking condenser. Batteries for the set consist of a pair of flashlight cells and a lightweight B unit of about 100 volts.

A later model, shown in Fig. 5, improved the original circuit in a number of details. The search head contains two transmitter and one receiver coils, as well as a one-turn winding which is shorted to upset the zero coupling between transmitter and receiver coils. This furnishes a quick test, as the operator can simply press a button on the control box and hear a signal in the phones, if the apparatus is in order. The oscillator in the newer model is a 1G6-GT, hooked up in a pushpull circuit with a 1,000-cycle transformer.

Tuning is also used in the headphone unit of this receiver, peaking it at the oscillator frequency. The earpiece is in fact called a "resonator."

The control box compensators consist of windings on retractable cores, two being used for capacity, and one for resistance compensation. Cores of the reactive balancers are of brass, of the resistive compensator, iron.

Still other detectors have been constructed which give different indications for different types of metal, distinguishing between magnetic and non-magnetic material. This can be done by distinguishing between lagging and leading phase angles in the currents set up by losses introduced into the magnetic field.

**Thanks are due to the International Detrola Corporation, for information and photographs, and *Electronic Engineering* (London) for material used in this article.**

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## THE TRANSIGENERATOR

*(Continued from page 715)*

lator 100 percent. From this, it can be seen that only a small voltage is required to produce the 30 percent modulation required by the I.R.E. Standards Committee. A high percentage of modulation in a signal generator is often useful when checking a receiver which is so badly out of alignment that high output is necessary to force the signal through.

The capacitor which connects the S2 "on" contact to ground keeps r.f. energy out of the a.f. circuit; it has negligible effect upon the 400-cycle output.

The r.f. oscillator may be externally modulated if desired. Thus an a.f. source, such as a variable-frequency audio oscillator, phonograph pickup or microphone, may be superimposed upon the r.f. test signal, through the external modulation jack.

Fig. 2, however, includes this in dotted line form, since it is still in the "plan" stage. Clearly, Switch S2 must be changed to the single-pole three-position type. The jack will be mounted on the panel near S2. Another condenser goes from the jack to the chassis as shown.

Any small power transformer may be used. If the voltage at point "X" exceeds 280 volts, a 10-watt resistor may be used in place of choke L5. The value must be found by trial, and this can be simplified by employing a resistor with an adjustable slider. If the voltage at point "X" does not exceed 280 by more than 15 or 20 volts, it will be simpler to reduce or remove the input filter condenser. Small changes in rectifier output voltage may also be compensated for by varying the bleeder (decrease it to reduce the voltage).

### GENERATOR CALIBRATION

Much can be said regarding methods of calibrating a Signal Generator. Nevertheless, so much material has appeared in past articles in RADIO-CRAFT, that it would be redundant. The constructor is referred to the following articles: "Calibrating Generators," Jack King, April, 1944, p. 412; "Signal Generator," M. E. Blaisdell, Nov., 1945, p. 121; "Signal Generator," Bob White, Jan., 1946, p. 243.

It is to be emphasized that the Transigenerator has been designed for extreme simplicity. It is apparent from the photographs, for instance, that no under-chassis shielding was necessary.

Many improvements can be thought of by the more advanced technician. For example, the r.f. and a.f. units can be isolated from one another. Then, modulation, internal and external, could be accomplished in a separate mixer tube such as the 6SA7 or 6L7. The r.f. output would then be taken from the mixer stage, isolating the signal generator from the circuit under test in a more thorough manner. This would also result in a wider tuning range. Other improvements will probably suggest themselves to the experienced technician.


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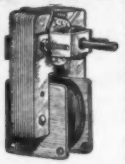

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## INSIDE THE HANDIE-TALKIE

*(Continued from page 703)*

### DIRECTION FINDER, TOO

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This is a directional loop antenna used in place of the non-directional telescoping antenna. A modification kit was also provided that permitted the operator to use external headphones.

The loop consists of two windings, a single turn secondary winding and a four turn primary winding. The primary of the loop is tuned by a 100-μμf variable condenser. The loop assembly is connected by cable to a matching transformer that matches the impedance of the loop to the input impedance of the receiver. The matching transformer screws to the antenna cap stud and consists of a tuned auto-transformer. Its output lead is equipped with a clip that fastens to the vertical antenna.

When the loop and transformer have been tuned to give maximum response from the desired station, the loop is rotated through 360 degrees. There will be two points where the signal strength drops to a sharp null. These points will occur when the loop is broadside to the direction of the signal source. This will indicate that the signal is coming from one of two directions 180 degrees apart. To determine which is the true direction, a "Sense Button" permits the body to act as a vertical antenna. Rotating the loop 90 degrees in each direction from the null will produce a stronger signal in one direction than in

*(Continued on following page)*

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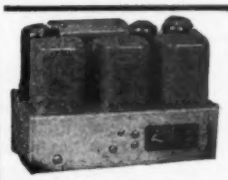

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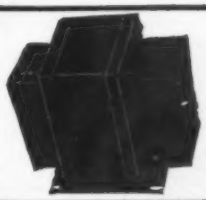

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*Speaker Opening in center of front side.

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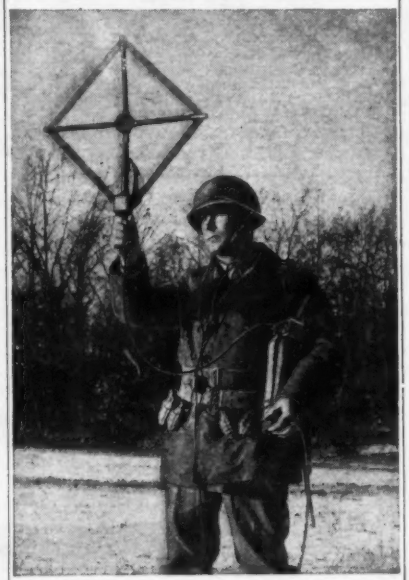
**Television** receivers will begin to reach the market this fall, David Sarnoff, president of the Radio Corporation of America, told the stockholders at the company's annual meeting held recently.

## INSIDE THE HANDIE-TALKIE

*(Continued from page 723)*

the other. When the loop is turned to the loudest signal, an arrow on its base indicates the true direction. The thumb is then removed from the "Sense Button" and the loop turned to the original null. The operator may then direct himself toward the transmitting station by traveling in a direction perpendicular to the plane of the loop in null position.



The Handie-Talkie used as a homing device.

## 430 MC WITH A 6F4

*(Continued from page 705)*

ens the radiated wave due to undesirable frequency modulation. This is not too disadvantageous for communication but may be undesirable for experimental work. For lower modulation percentage, Fig. 7 may be used.

This transmitter can be easily adapted to voice communication by using some of the principles and circuits given in the transceiver article (May). It is stable and gives more output than can be obtained from a transceiver.

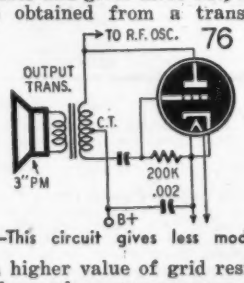



Fig. 7—This circuit gives less modulation.

With a higher value of grid resistance it can be used as a super-regenerative receiver, but because of the type of construction, it is better adapted for a semi-fixed frequency transmitting outfit. Until the final design is complete (at least) it is a good idea to leave a plate milliammeter in the circuit to indicate conditions.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**Television** receivers will begin to reach the market this fall, David Sarnoff, president of the Radio Corporation of America, told the stockholders at the company's annual meeting held recently.

## CATHODE FOLLOWERS

*(Continued from page 692)*

This circuit is not recommended where high input impedance is important.

In this arrangement, operation of the cathode follower is similar to the previous type, but the input signal appears across the grid resistor $R_G$, which with $C_G$ develops grid bias when signal is applied, as in a grid leak detector. Positive input signals of high amplitude soon drive the tube into the region of grid saturation. Larger negative signals can be handled because of the lack of initial negative bias.

Output of the stage is still taken from across the cathode resistor $R_K$, and output voltages and impedance are of the same order as in the previous circuit.

When a circuit is required to accomodate high-amplitude input signals of *both positive and negative polarities*, a modified cathode follower (Fig. 3) is employed which changes biasing arrangements and results in improved operation.

A triode is used in this modified circuit (Fig. 3). The cathode resistor is divided into two parts: $R_{K1}$ and $R_{K2}$.

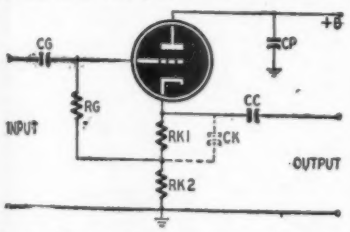


Fig. 3—Circuit for large a.c. grid swings.

The input signal appears across the grid resistor $R_G$ and the cathode resistor $R_{K2}$ in series. Value of $R_{K1}$ establishes a no-signal bias which permits the triode to operate about mid-way along the tube's characteristic curve—between plate-current cut-off and grid saturation.

Grid of the tube is thus allowed to swing to greater positive and negative values without grid saturation or cut-off than was possible in either of the two previous types of cathode followers.

This circuit (Fig. 3) might appear to lack the necessary feed-back arrangement. But it should be noted that the output voltage is acting effectively in series opposition to the input voltage—the required condition for degenerative feedback.

A variation of this circuit provides output reproduction of large negative and positive input voltages.

The only difference is the addition of a cathode condenser $C_K$ to the circuit of Fig. 3.

Another modification of the basic cathode follower is shown in Fig. 4. It supplies a matched, paraphase (push-pull) output.

Normally, there is no load in the plate circuit of a cathode follower. But in this arrangement (Fig. 4), a resistor $R_P$ is inserted in the plate of the triode. The value of this plate resistor is exactly equal to that of the cathode resistor $R_K$.

Since the same plate current flows through *both* resistors, changes across each resistor will be the same in voltage *but opposite in polarity*. During positive-going input signals, the cathode output is positive-going but the plate output will be negative-going. The two output waveforms have the same amplitude and shape.

Thus it is possible to obtain a distortionless push-pull output from a single

*(Continued on following page)*


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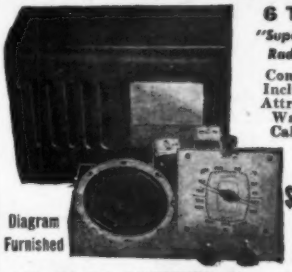

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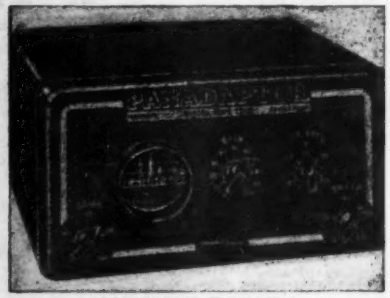

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## CATHODE FOLLOWERS

*(Continued from page 725)*

vacuum tube operating as a cathode follower.

Triodes most desirable for use as cathode followers should have a high value of transconductance—high amplification factor, and fairly low plate resistance—to approach unity amplification and provide a high-amplitude voltage output.

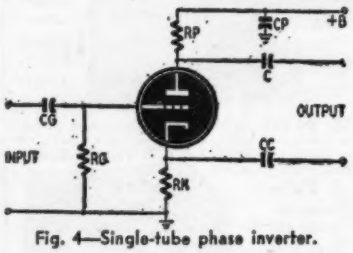


Fig. 4—Single-tube phase inverter.

### USES OF CATHODE FOLLOWERS

Many are the uses of the cathode follower in radar, television, and industrial electronic applications.

Three of the most important ones, all related, are illustrated by the R-C coupled amplifier circuit shown in Fig. 5. Three cathode followers are used: V1 for input coupling, V3 for isolating, and V5 for output coupling.

Since a cathode follower places no appreciable load on its preceding stage, it is particularly useful as an input coupling device (V1 of Fig. 5). Negligible power is drawn from the signal source. Because of the low input capacitance, there is practically no input distortion due to phase shift or current drain.

When d.c. as well as a.c. components of the signal waveform are to be transmitted, the cathode follower may be connected *directly* to the preceding stage without the use of a coupling condenser.

As an isolating stage (V3 of Fig. 5), a cathode follower places a low effective capacity in parallel with the grid and plate coupling resistors of the preceding stage (V2). Because of its low output terminal impedance, the cathode follower (V3 of Fig. 5) prevents phase and frequency distortion of its output signal due to input capacity effects of the following (V4) stage.

Thus a degree of separation or isolation between amplifier tubes V2 and V4 is maintained with negligible loss and without introducing distortion or otherwise affecting the signal waveform.

It is as an impedance-matching or impedance-changing device that the cathode follower is unsurpassed, and because of its low output impedance, it is most widely used in electronics as an output coupling stage (V5 of Fig. 5).

Electronically, the advantage of a cathode follower over a transformer is that the output terminal impedance of a cathode follower is *independent of frequency* over a wide range, providing distortionless transmission of the sig-

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nal waveform. Economically: a simple and inexpensive tube replaces a costly and hard-to-get transformer.

Matching of a video amplifier (having this standardized low-cost cable. to a transmission line (of very low impedance) can be accomplished practically only by a cathode follower.

Complex wave shapes are transmitted over long distances via low-impedance lines or coaxial cables. A cathode follower stage provides the low-impedance transmission source.

A cathode follower can also be used as an output stage to drive a dynamic loudspeaker—see RADIO-CRAFT, April, 1945—by connecting an audio output transformer directly in the cathode of the tube. The low impedance (output) of the cathode follower provides a high degree of damping which generally *improves* the overall performance of an audio loudspeaker. The large negative feedback of the stage results in an almost-distortionless audio signal output (if the circuit is carefully designed).

It is employed to great advantage to match high-impedance outputs to coaxial or concentric lines of considerable physical length. Such a cable—because of its distributed inductance, capacitance, and resistance—represents a low impedance. Only a cathode follower can match that impedance to the high impedances encountered at the output terminals of video and pulse circuits.

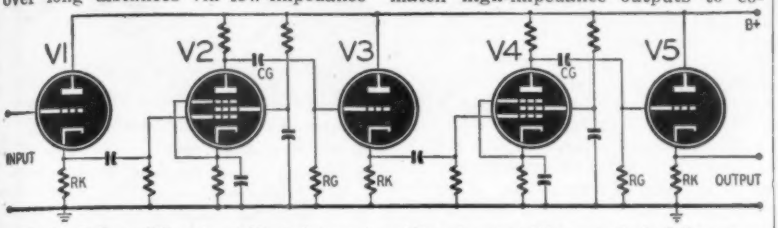


Fig. 5—R-C amplifier. Input V1, isolating stage V3 and output V5 are cathode followers.

## BROAD-BAND ANTENNA

*(Continued from page 681)*

side of zero azimuth, or target, until half-voltage points are reached.

Element lengths and spacing dimensions for this array are as follows, and are further shown in Table 1 and Fig. 1.

*Element Lengths*

Director: .41 wavelengths
Driven or Center Element: .47 wavelengths
Reflector: .52 wavelengths

*Element Spacing*

Director to Center Element: .10 wavelengths
Center Element to Reflector: .15 wavelengths

For ready use, spacings and element lengths are shown in Table 1 for operation on several useful amateur, FM, and television frequencies. In all cases the center element is fed by standard 50-ohm coaxial cable, preferably Joint Army-Navy Approved RG-8 Cable, now readily available in quantity as military surplus, or from manufacturers producing this standardized low-loss cable.

Properly and carefully constructed, the array will operate with complete satisfaction over a 15 percent frequency range, or over 2,100 kcs at 14 megacycles, 4,200 kcs at 28 mcs, 7,500 kcs at 50 mcs, and so on.

Experience with this type of antenna shows that although its 15 percent frequency response factor is technically short for an idealized bandwidth for television reception, it performs exceptionally well, and is altogether superior to a single folded dipole at the same height above ground. At the time of writing, four sets are using the array, providing excellent reception 40 miles from the Empire State Building transmitting point in New York City.

Though not common among amateurs due to the fact that little data has ever been published on the subject, two three-element arrays stacked over each other and properly phased offer a considerable improvement over the one-array antenna. In a great many installations where the entire supporting mast is rotated, or the direction fixed, the use of a lower tier will give considerably greater power gain, and far more efficient use of the lower *vertical* angles of radiation and reception. These lower vertical angles contain the pay dirt not only for long distance contact, but for u.h.f. work. Actually, a great many antennas, though erected with precision and costly materials, are but some 30 percent effective solely because their best recep-

*(Continued on page 732)*

| Center Frequency | Director Length, ft. | Driven Element Length, ft. | Reflector Length, ft. | Director to Driven El. spacing | Reflector to Driven El. spacing |
|---|---|---|---|---|---|
| 14,000 kcs | 28 ft. | 32.6 | 35.3 | 6.95 | 10.4 |
| 28,500 kcs | 13.8 | 16.3 | 17.8 | 3.4 | 5.18 |
| 50,000 kcs | 7.8 | 9.2 | 11.2 | 1.95 | 2.93 |
| 52,000 kcs | 7.7 | 8.8 | 9.8 | 1.87 | 2.82 |
| 56,000 kcs | 7.1 | 8.3 | 9.2 | 1.76 | 2.62 |
| 97,000 kcs | 4.2 | 4.7 | 5.2 | 1.1 | 1.65 |
| 146,000 kcs | 2.7 | 3.2 | 3.5 | .67 | 1.01 |

TABLE I


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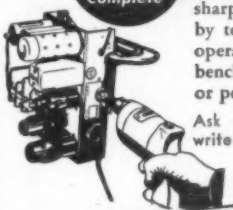

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# COMMUNICATIONS

## A CANADIAN COMMENTS

*Dear Editor:*

I would like to comment on the letter by Mr. E. B. Menzies that was printed in the April issue.

Although I am a Canadian, I feel very keenly his contempt for the American radio serviceman. I have converted quite a few sets and since September 1st, 1943 I have repaired 2000 sets in a small Canadian town. I have had numerous American sets in my place with no available diagrams for them. I thought nothing of repairing and aligning these sets as aligning receivers is one of the many things that we learn when training. One of the prominent questions on our provincial exam is: "How would you align a receiver if you did not know the intermediate frequency?"

Ohm's Law is only one of the many things to be taken into consideration in tube replacement; interelectrode capacity, cut-off points and proper load matching are also important. In replacing a 12SA7 with a 12A8, the oscillator coil has to be considered. I believe Mr. Queen's articles on this subject were very useful, especially to new servicemen.

Well, enough on the subject. In spite of what others think about RADIO-CRAFT, just keep on making it in the same old way as it's a mighty good mag that way.

E. SCHURMAN,
*Vermilion, Alberta*

## FIVE-CIRCUIT ERROR

*Dear Editor:*

There is a slight error in one of the schematic drawings in my article, Five New Circuits, which was printed in the April issue. In Fig. 4 on page 495, there are two resistors connected in series between the 12C8 diodes and ground. The drawing shows a .01-μf condenser by-passing the 250,000-ohm resistor. This condenser should have been .0001 μf as the one shown will ground the a.f output of the diodes.

Also, in Fig. 1-b on page 467, there is a drawing of the exterior appearance of the receiver described in Fig. 1-a. The text mentions that an "on-off" switch is shown on the drawing. This switch, has, however, been accidentally omitted in the drawing. It should have been located in the middle of the top of the larger section of the case.

Neither of these errors is of great importance, as any good radioman would soon spot the first one anyhow, but I thought you might like to have them called to your attention in the event that you had not already noticed them. On second thought, I trust that the first error is not a mistake in my drawing, my schematics never were any too clear!

ROY M. CATER,
*Washington, D. C.*


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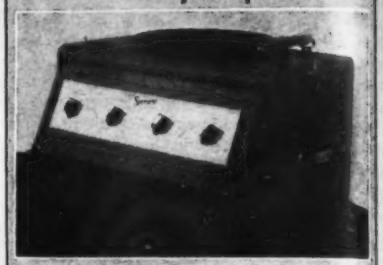

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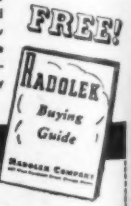


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## THE RACKETEERS WILL GO

*Dear Editor:*

I have just read the article on Racketeering Repairmen in the April issue. Who is to blame for this racketeering? Manufacturers of adapters and tubes should also share a part of the blame for this situation.

Personally I think the boys did one fine job working all hours of the night and day trying to keep the public supplied with radio service, and to use what parts and tubes the emergency would let us have to work with.

The critics should also take a peek at some of the products of self-styled servicemen who attempt to fix their own radios, finally wind up by taking the radios to a service shop for repairs and then squawk at the price. These men are the biggest gripers about enormous prices charged by the serviceman. They fail to realize that a great part of the labor charge goes toward straightening out the mess they have made.

These radio profiteers and racketeers will cut their own throats in time, because the public will stand for just so much of this sort of thing. They will slowly but surely weed these people out of the ranks of servicemen.

F. S. M. BAILEY,
*Carrizo Springs, Texas*

## SERVICEMEN'S PROBLEMS

*Dear Editor:*

Although I am not an ex-serviceman, I think it only fair that I should be accorded the right to answer some of the assertions made by Mr. Massey on Ex-Servicemen vs. Manufacturer.

I refer particularly to the time-worn phrase, "Draft Dodger". Mr. Massey seems to apply it to everyone who was not a member of the Armed Forces. I received my entrance exam and was rejected as were many others. If it were possible to "dodge" the draft (of which I have no proof) how is he going to differentiate between those who were rejected and those who "dodged"?

Did Mr. Massey join the Armed Forces through deep-rooted patriotism, or did he find himself there without any voice in the matter? If he studies the problem, he will realize that everyone with whom he talks is a potential customer and that his attitude is incompatible with the principles of sound business. (These customers might not, for many reasons, have been members of the Armed Forces).

EDWIN SLAVIN,
*Philadelphia, Pa.*

(We regret that the term "draft dodger", which carries an implied insult to everyone who did not find himself in the armed services during the war, was used in this magazine. Mr. Massey, like many radiomen who find themselves in difficulties, due to their absence from their home areas during the war, no doubt felt very strongly about his problems and in his search for vehement speech, used terms which he himself probably would not care to employ after calm deliberation.—*Editor*)


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## RADIO-ELECTRONIC QUIZ

*How thoroughly have you mastered the contents of this magazine? Try the following quiz as a test:*

1. Is radio receiver production increasing steadily? See page 674.
2. What bands are now open to amateur operation? See page 675.
3. On what principle do mine detectors work? See page 676.
4. How may an antenna's frequency response be broadened? See page 681.
5. What is an Image Dissector? See page 683.
6. How do you tune a Handie-Talkie? See page 684.
7. What is the Transitron circuit? See page 686.
8. Can you name a type of tuned circuit adaptable to 400 mc and higher? See page 688.
9. What is the resistance of constantin? See page 700.
10. How many types of waves may be used to transmit intelligence? See page 718.

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## BOOK REVIEW

**PULSED LINEAR NETWORKS, by Ernest Frank. Published by McGraw-Hill Book Company. Stiff covers, 5½ x 8½ inches, 267 pages. Price $3.00.**

This book was prepared principally for the power and communication engineer and for the engineering student. A thorough understanding of differential equations is presupposed.

The opening chapter describes the difference between transient and steady-state currents which may exist in an electrical network. This chapter is illustrated with actual and equivalent circuits showing lumped capacitance and inductance or combinations of both.

The remaining eight chapters are devoted to the various possible combinations of R-C-L that may appear in a network. Differential equations, diagrams and curves are used to fully explain the effects of currents in these curcuits. A chapter on practical applications shows how measurements may be made on actual amplifiers and shows the relationships existing between each individual component and all others to determine the characteristics of the circuit under actual conditions. A number of problems are included at the end of each chapter to illustrate the fundamentals of such circuits and should be helpful in getting a better understanding of the theories of operation.

**PRACTICAL RADIO AND ELECTRONICS COURSE, by M. N. Beitman. Published by Supreme Publications. Hard paper covers, 8½x10½ inches, 332 pages. Price $3.95.**

This book is designed for home-study in the fields of radio and electronics and is surprisingly thorough for a book of this kind. It has 53 easily understood lessons illustrated with 387 drawings, charts and photographs.

In the first fourteen lessons, the reader is acquainted with the various components and circuits that go into the making of the average home receiver. Diagrams ranging from a two-tube regenerative receiver to a nationally known communications receiver are used to explain the workings of the various portions of a radio set. FM, television and a.f.c. circuits are explained in separate lessons.

Servicing equipment is covered in two lessons which include schematics of the equipment and drawings showing how instruments are used for servicing.

Transmitter theory is covered in one lesson that includes photographs and drawings of low-power phone and c.w. amateur transmitters. This lesson is followed by an interesting lesson on antennas and radiation.

The remaining twenty lessons are devoted to various kinds of electronic instruments and control circuits. They are not as complete as the earlier lessons, including only the barest essentials on the operation and characteristics of the equipment described.—*R.F.S.*


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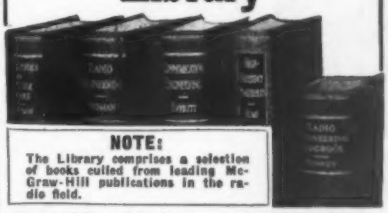

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## BROAD-BAND ANTENNA

*(Continued from page 727)*

tion and transmission is concentrated at an angle above the horizon *for higher* than the angle of incoming signals, or optimum angle for outgoing signals.

For instance, long time surveys of the New York to Europe radio path show that the mean and therefore most effective average vertical angle for transatlantic transmission and reception to be 11 degrees for 14 mcs, 11½ degrees for 15 mcs, 9 degrees for 16 mcs, 8½ degrees for 17 mcs and 7 degrees for 18 megacycles. Average optimum angles for 28 mcs run even lower.

Few amateur antennas, and this goes for a great many amateur rotary beams, put out a major proportion of their power at these angles. Actually some 5 percent of their power accounts for their DX operation. This 5 percent may be three or four times that delivered by a simple dipole at this angle and therefore justify any claim for a 6 db increase over a dipole. But lowering the angle of delivered power to a genuinely useful figure, for instance 11 degrees on 14 mcs, produces truly remarkable results.

This increased power at the vertical angles of 5 degrees and 10 degrees, which account for the major signal power of 90 percent of our international overseas DX, and the same proportion of television and frequency modulation signals, is possible in a highly compact space by using, for example, two of these broad band close-spaced arrays stacked one over the other and spaced an electrical half-wavelength. This is shown in Fig. 2-a, while Fig. 2-b details transmission line connections.

The upper set of elements is connected

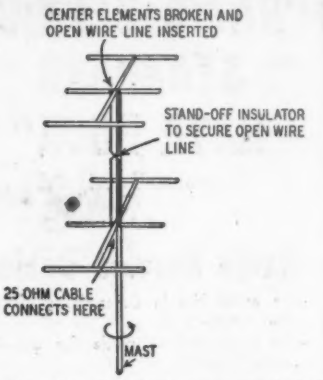

CENTER ELEMENTS BROKEN AND OPEN WIRE LINE INSERTED
STAND-OFF INSULATOR TO SECURE OPEN WIRE LINE
25-OHM CABLE CONNECTS HERE
MAST

Fig. 2-a—Two 3-element arrays stacked. The 25-ohm line may be paralleled RG-8 coaxial.

to the lower set by an open wire transmission line, transposed *once*. Two- to six-inch spacing of the line is satisfactory, the two-inch figure for higher frequencies. The length of this connecting line should be exactly an electrical half-wavelength at the mean operating frequency. The twin antenna, now a six-element array, is simply fed by paralleling two lengths of 50-ohm RG-8 cable together to offer a 25-ohm line, or the surge impedance presented at the lower junction of the upper and lower tiers.

If the upper and lower tiers are permanently secured to the mast, simultaneous rotation is possible simply by rotating the entire mast on a pivot, using circular rings attached to guy ropes to maintain the mast vertically.

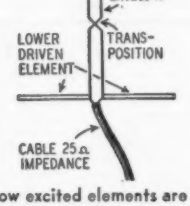
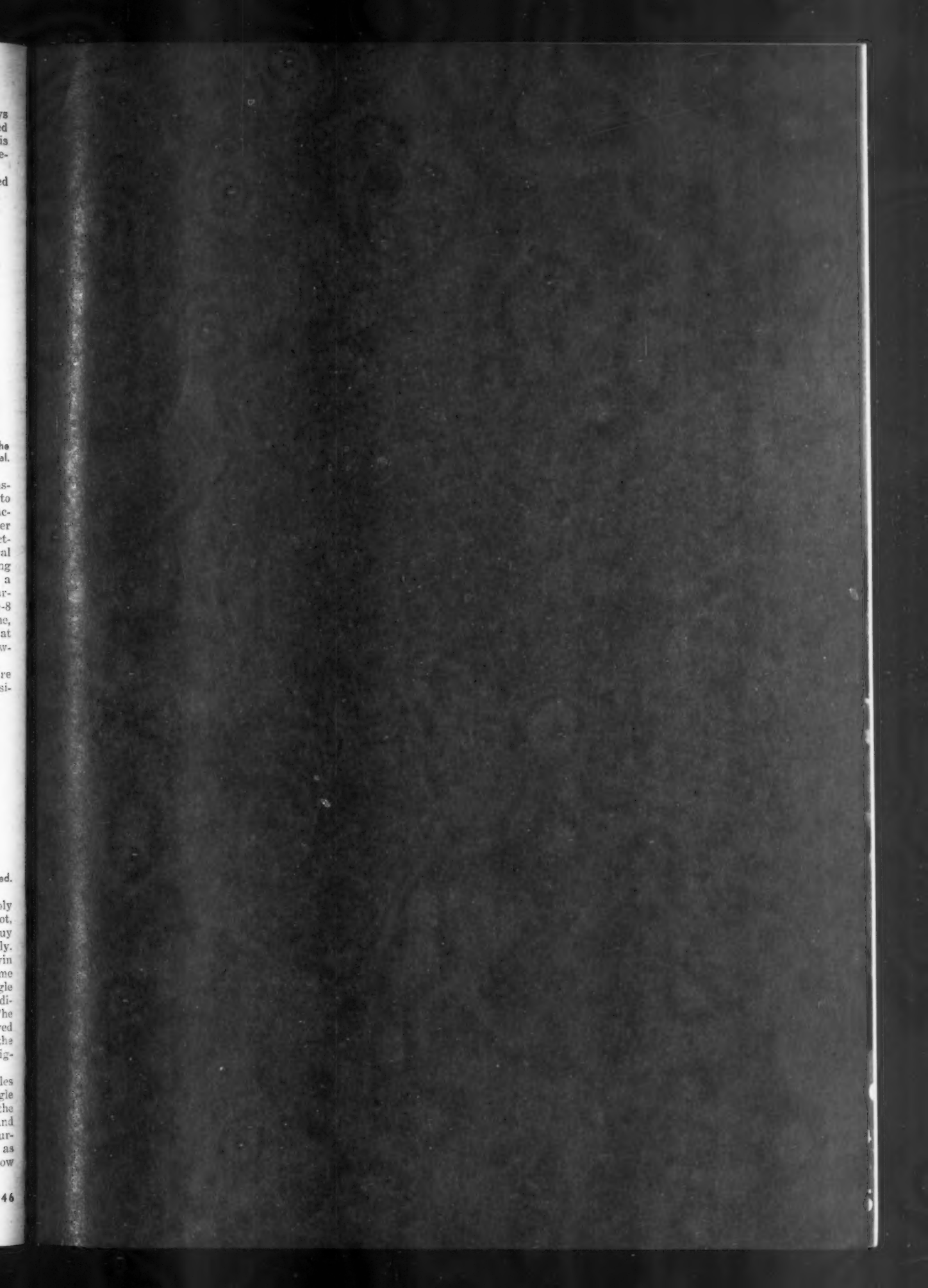



Fig. 2-b—How excited elements are connected.

In operation, this six-element twin antenna will have essentially the same broad-band characteristics of a single tier, while stacking will not alter dimensions of each section materially. The vertical angle of delivered and received signals will be reduced well into the lower region which produces loud signals at extreme DX.

Tests of this antenna at 10,000 miles show it to completely outclass a single three-element comparison rotary at the same average height and be far and away superior to a conventional four-element, close-spaced array as well as having a new freedom from narrow band operation.



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